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ECONOMIC ASPECTS OF LOCAL ELEVATOR ORGANIZATION

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA

BY

HUTZEL METZGER

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
JUNE 1926
MINNEAPOLIS

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ECONOMIC ASPECTS OF LOCAL ELEVATOR ORGANIZATION[1]

HUTZEL METZGER

INTRODUCTION

The proper business set-up of local elevators, as distinct from finance and organization for operation, is very important for the local grain marketing business. The relation of plant to volume and the combination of the cost elements (labor, management, building, equipment, and site) are significant factors affecting efficiency. This bulletin discusses the business set-up of representative elevators, the variations in economic organization, and the principal reason for variations in efficiency. The business practices of local elevators (buying, selling, storing, and hedging) will be discussed only as they relate to economic set-up. An analysis of these aspects of the local elevator business is given in another bulletin.[3]

SOURCE OF DATA

The data for this study were obtained by means of a survey made in co-operation with the United States Bureau of Agricultural Economics in the winter of 1925. The survey included 49 local farmers' elevators. Only those were selected that had been audited by a competent public accountant, and that were representative of regions in which varying kinds and amounts of grain are marketed and different types of farming prevail. Altho the data were obtained only from farmers' elevators, the analysis applies in considerable measure to independent elevators because of the similarity in organization and method of operation. The relative numerical importance of the different types of elevators in Minnesota is given in Figure 1.

All expenditures, purchases of grain, overages and shortages, volume of grain received and shipped, and purchases and sales of merchandise of the sideline business were taken from the annual and semi-annual audit reports. Monthly receipts, shipments, purchases, sales, and amounts of each kind of grain in storage were obtained from the records of the elevators. The storage data were checked against the reports of the amount of each kind of grain in storage that are submitted

[1] Published as Minn. Expt. Sta. Bull. 251.

[2] Now a member of the staff of the Division of Co-operative Marketing, Bureau of Agricultural Economics, U. S. Dept. of Agr.

[3] Minn. Agr. Expt. Sta. Bull. 224, "Management problems of farmers' elevators," by H. B. Price and C. M. Arthur, 1925.

monthly to the Local Warehouse Department of the Minnesota Railroad and Warehouse Commission.

A complete appraisal was made of all sites, buildings, and equipment owned by each elevator. Every elevator was measured and notes were taken on material and type of construction. Each piece of equipment was listed, with data on make, specifications, and peculiarities of installation. The basis of appraisal was replacement costs for the year

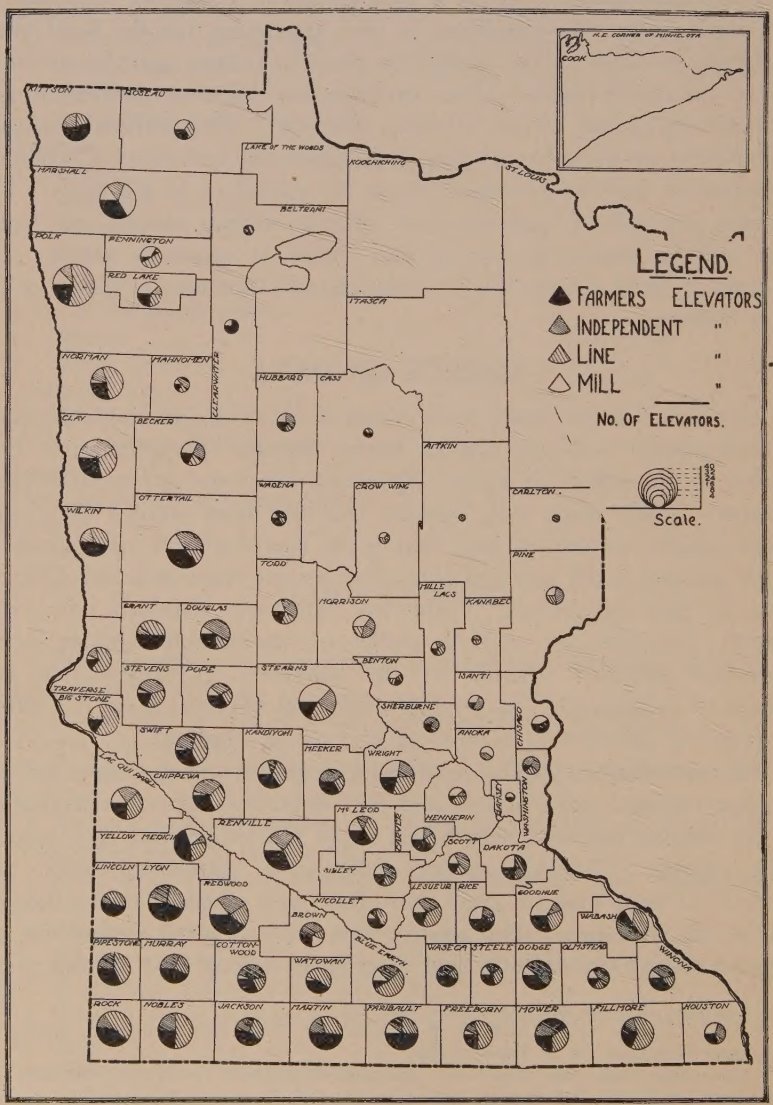

Fig. 1. Relative Number of Co-operative, Independent, Line, and Mill Elevators in Each County in 1926

of study. The valuations were made according to information from elevator construction companies. The rate of depreciation was based on the history of each elevator, its present condition, and the best judgment of line elevator managers and insurance and equipment companies operating in the area.

Insurance costs on buildings, equipment, grain, and sidelines were taken from the records. Most of the elevators carry insurance on the provisional premium adjustment plan, that is, a maximum blanket policy is carried and a weekly report of the amount and value of each kind of grain and merchandise in the elevator is made to the insurance company or to a commission company acting as agent for the elevator.

The inventories at the beginning and the end of the year were obtained from the balance sheets and weight statements of the annual audits. When this information was supplemented by records of monthly purchases and sales, the interest charges on stocks of grain and merchandise could be calculated. Records of expenditures show total amounts paid for taxes on grain as well as on buildings and equipment. The tax year does not coincide with the fiscal year of the elevator, hence an adjustment for this item was necessary in the case of grain. The tax on grain is assessed on the basis of turnover regardless of price, and is uniform for the state—one-half mill on each bushel of wheat and flax and one-fourth mill on each bushel of all other grains marketed.

Information was obtained as to the number of hours of management and of both regular and temporary labor employed during the year; also estimates of additional labor necessary to carry on a sideline business. The amount of labor used in record keeping and the time actually given to the sideline business by each emp'oye were obtained. Estimates were secured of the time necessary to receive and weigh a wagon or truck load of grain. Scale tickets were counted for enough loads to determine the average size of a load of each kind of grain received at the elevator. Estimates were also obtained on the length of time required to carry an average carload of each kind of grain through all the processes applied to it from the time the farmer arrived with the load until it was in the car and billed out. This involved information on rate of receiving each load, elevating, and loading out as well as kind of grain and number of bushels cleaned, and the capacity of the cleaner. The rate of moving grains for conditioning or mixing and the amounts so treated were noted, altho few elevators performed these operations in 1923-24. The number, size, arrangement, and use of bins were noted in order to arrive at a fair basis for distributing building costs to different grains.

METHOD OF ANALYSIS

A cost system was set up and the data for each elevator were analyzed. The elementary costs of labor and management, building and site, equipment, and other direct items were first derived through this analysis, also cost of individual grains and combination costs. These costs were then grouped by averages and ranges, and statistical methods were used to explain variations. This study was undertaken to discover the facts that cause variations in costs.

ELEVATOR ORGANIZATION

Figure 2 shows the arrangement and construction plan of a typical country elevator of 30,000 bushels capacity.

The farmer's wagon is driven on the combination scales and dump (1) in the driveway. After being weighed, the grain is allowed to run into the pit (2), which may be of concrete, iron, wood, or wood lined with steel. The elevator may have several such pits or only one pit with a partition. The grain flows by gravity to the bottom of the pit into a receptacle called the boot (3). At the bottom of the leg (4), in which is located the elevating machinery, a series of buckets fastened to an endless chain or belt carries the grain through the leg to the head (5). Here it is dumped into a movable distributing spout (6), which may be connected with any bin desired or with the direct loading spout (7).

If an automatic weighing-out scale is located in the cupola, the distributor directs the grain into it. There it is automatically weighed and the weight registered. The grain then flows by gravity to the railroad car. If the automatic scale is on the work floor just above the pit, the grain flows from the bins into the scale, and thence into the pit. It is then elevated to the cupola, whence it goes to the loading spout. The elevator plan in Figure 2 provides for a hopper scale of 60 bushels capacity (8) on the work floor (9). This scale is operated by hand. Some elevators have a small bin, known as the loading bin, above the hopper scale, into which the grain to be loaded out is always run. Grain to be cleaned flows from the bin into the cleaner (10) on the work floor, then falls into the pit, and is elevated to the proper bin.

The bins are located on both sides of the work floor and over it. Those over the work floor are usually hopper bottomed and extend to within 8 or 10 feet of the floor. The elevator of Figure 2 has 17 bins: 6 extend to the floor, 4 are hanging bins within the outside full-length bins, and 7 are overhead bins with hopper bottoms.

Power is furnished by engines and motors. Engines are located in the powerhouse, across the driveway from the elevator. A belt runs to a line shaft sometimes attached to the elevating machinery in the

boot, but more often to a rope or belt drive connected with the head in the cupola. If motors are used, they are usually in the cupola, with a silent chain drive to the head. A separate motor may be employed to run the cleaner and the air compressor if an air dump is used. The elevator illustrated has two legs running into one pit. The elevating machinery is driven by the two motors (11) in the cupola, a silent chain-and-sprocket drive connecting with the pulley in the head. The cleaner is operated by a separate motor just over the cleaner and above the work floor.

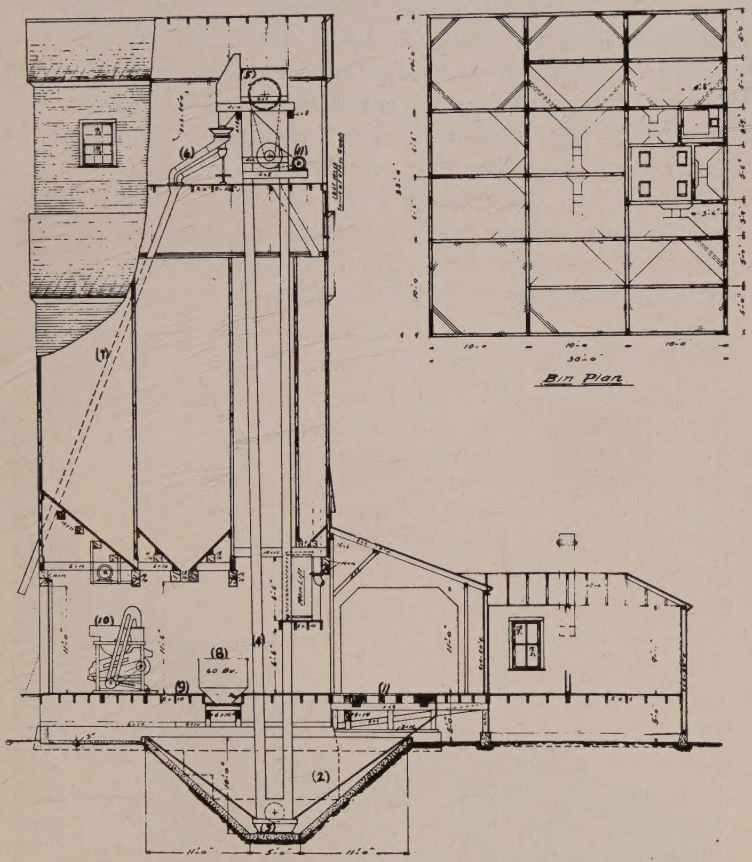

Fig. 2. Longitudinal Section of Local Grain Elevator
(Courtesy T. E. Ibberson Co., Minneapolis)

CLASSIFICATION OF COSTS

Costs are first grouped according to the various elements—costs that are relatively fixed (on site, buildings, and equipment), variable costs for maintenance, labor and management, interest and insurance on grain and merchandise, supplies, and miscellaneous items. No attempt was

made to resolve the total costs into process costs. For example, the whole plant usually works as a unit, tho most of the processes could be performed singly. On a busy day the power unit may furnish power for dumping, elevating, cleaning, and loading simultaneously. The time the manager gives to any one of these operations may be small. If any part fails to function, it receives more of his time but it may receive less power. While the manager is supervising these processes, he may also be buying, receiving, weighing, looking after the records, or selling merchandise. Any equitable distribution of labor or power costs, with the best of detailed records, would therefore be difficult. Costs for individual grains present a problem somewhat different, tho still complex. Only one grain at a time is usually handled, so it seems more logical to distribute costs to the various grains than to the processes.

Variations in total elementary costs are considered first on the basis of all grains taken together, with an equal weighting for each bushel. Later, variations for the different grains will be considered.

The extreme range in costs of handling, as indicated in Figure 3, varied between elevators from one to 12 cents per bushel, with an unweighted average cost of 5 cents. More than 80 per cent of the

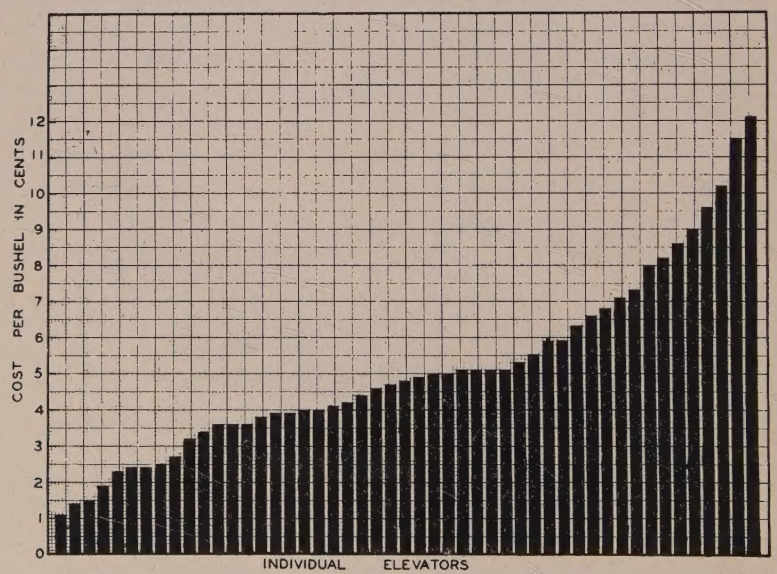

Fig. 3. Range in Costs per Bushel of Handling All Grain in 49 Minnesota Elevators

elevators had costs ranging from 2 to 9 cents per bushel. However, the variations in costs and the causes of variations are more significant than total costs as indexes of efficiency.

Table I gives the relative importance of the elementary costs that make up the total. The last item might be further divided. It includes

telephone and telegraph, market information, auditing, supplies used in lining cars, office supplies, legal fees, and other small items. Variations in these expenses are wide from elevator to elevator, but where business is relatively large this item constitutes but a small proportion of the total, hence they have been grouped.

TABLE I

ELEMENTARY COSTS OF 49 LOCAL ELEVATORS

Item	Per cent of total
Labor and management	46
Sideline rental and buildings	20
Equipment	12
Electricity and gasoline	4
Interest on grain	5
Insurance on grain	3
Taxes on grain	1
Miscellaneous	9
Total	100

Almost half the total cost of handling (46 per cent) is for labor and management. Expenses for building and site constitute 20 per cent; for equipment, 12 per cent; for electricity and gasoline, 4 per cent; for insurance on grain, 3 per cent; for taxes on grain, 1 per cent; and for miscellaneous items, 9 per cent. More detailed information, especially regarding the last item, will be given later. The average volume handled by these elevators was 121,391 bushels, the range being from 25,000 to 703,000 bushels. The ordinary range was from 32,000 to 450,000 bushels.

Labor and Management

Expense for labor and management includes all money paid for the services of the elevator manager, any assistants—a second man, helpers, clerks, or bookkeepers—and extra labor hired for a short time or during the peak load period. Any special labor required for handling sidelines, such as unloading coal, which is seldom done by the regular employes, has been carried in the accounts as a part of the cost of sideline merchandise and has been so treated here. The loading of fuel on the farmers' wagons is nearly always done by the farmers themselves. The cost of labor on repairs or renewals has been treated as a part of the cost of the repairs and not as a part of the expense of labor and management.

The records show that in 30 of the 49 elevators only one man, usually known as the manager, was employed regularly. Twelve of the 30 elevators hired no extra labor. The grain handled by this group ranged from 25,000 to 159,000 bushels. Five of the 30 elevators hired less than 25 hours of extra labor, 2 less than 50 hours, 3 between 50

and 100 hours, 2 between 250 and 300 hours, 2 about 500 hours, and 4 more than 700 hours, an average of 167 hours. The volume handled by the elevators employing only one regular man ranged from 25,000 to 200,000 bushels, the elevator handling the latter amount hiring only 100 hours of extra labor.

Seventeen elevators employed one regular helper. Ten of these hired no extra labor, 7 hired from 20 to 715 hours each, the average being 136 hours. These helpers, except one, assisted the manager in practically all his duties except selling. One elevator used the helper as a bookeeper and an assistant in selling the sidelines, at least half of his time being given to the sideline business. The volume of business for this group ranged from 53,000 to 449,000 bushels, the low-volume elevator hiring no extra labor while the high-volume one employed 715 hours.

Of the remaining 2 elevators, one employed a manager, a helper, and a bookkeeper in addition to 450 hours of extra labor. It handled 703,000 bushels of grain. The other had a manager, two helpers, and a bookkeeper.

The most usual cause for hiring additional labor was the heavy receipts of wheat and oats during the fall months, and of corn during December and January. Small amounts of extra labor could usually be accounted for by sickness of the manager, by his attendance at the annual meeting of elevator managers and officers, or by vacations. Occasionally extra labor was employed for night work when the movement of grain was large or the distribution of cars was poor.

The importance of the effect of seasonal variations in marketing upon the amount of extra labor employed is in part indicated by the rate of farm marketing. During the 15-year period, 1909-23, an average of 27.5 per cent of the wheat was received during September, 18.1 per cent during October, and 14.1 per cent during November. Sixty-nine per cent of the wheat had left the farm by the end of November and 78 per cent by the end of December. Shipments are heaviest in the same months, but lag somewhat behind receipts. Oats are marketed at about the same rate in Minnesota, altho slightly earlier; rye at about the same rate and the same time as wheat. The heaviest marketing of corn occurs in December and January.

The kind of grain marketed determines the time of year that extra labor is employed; the combination of grains determines to some extent the length of time it is employed and the amount of extra labor necessary to market a given volume. For example, a larger volume of grain can be handled by the regular employes of elevators in southwestern Minnesota than by those in other parts of the state, because these elevators market chiefly corn and oats, whose peak loads are reached three

months apart (Fig. 4). A necessary corollary to this statement is that a combination of grain that spreads the receipts over a long period increases the handling power of plant and equipment.

As about 80 per cent of the grain has been received by January 1, labor requirements of ordinary local elevators are relatively small after that date. A large sideline business or the cleaning of a large part of the grain in winter may modify this, but as two-thirds of the annual shipments of wheat are made by January 1 and as wheat is the most

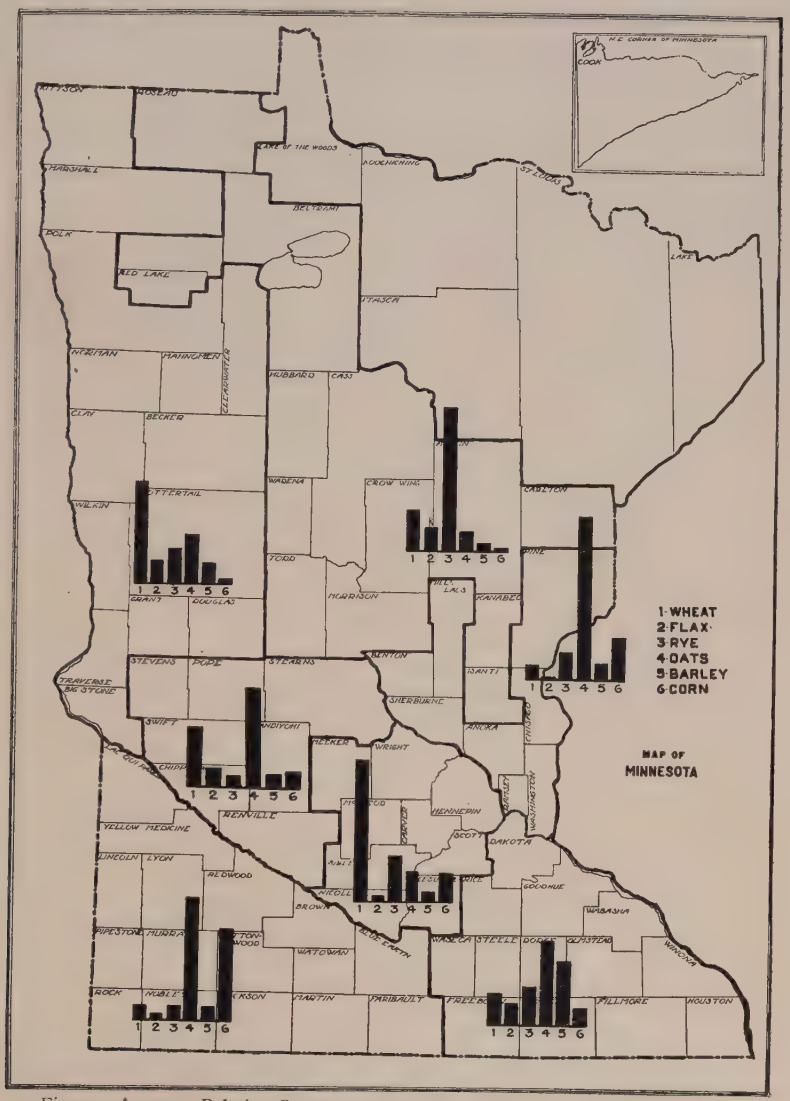

Fig. 4. Average Relative Importance of Grains Marketed Through Farmers' Co-operative Elevators, by Districts

important to the grains cleaned, the extra labor for cleaning is relatively unimportant. If part of the other grains can not be cleaned because of inadequate machinery or if it is not worth while to clean them, the extra labor would be still less important.

The time spent at the elevator by the manager and his helpers depends chiefly on the habits of the manager, the patrons, and the wishes of the board of directors. It seems not to be much influenced by the volume of business or by the amount of time required to handle the different grains. Most elevators close by six o'clock in the evening except in September and October, when they are often open long after dark. There is a much greater variation in the opening time. In the middle of the winter many do not open before nine o'clock, others open at seven. Those that do a large sideline business usually open earlier and with more regularity. Whether they are loading grain or sitting around the office fire, this time is considered as a part of the hours worked. It is really an overhead labor expense, the cost of which must be allocated to the various processes.

A tabulation of the hours worked by elevator managers shows a range from 2,400 to 3,443 hours per year, the average for those having no helpers being 2,845; for those with one regular helper, 2,736 hours; for those with two regular helpers, 2,400 hours; and for those with three helpers, 2,400 hours. Only one elevator in each of the last two groups varied widely from the average of its class. The most time worked by any manager having no helper was 3,443 hours; and the least was 2,500 hours. For those having only one helper, the most was 3,130 hours and the least 2,400 hours. The average time put in by helpers where only one was employed was 2,703 hours, and where there were two or more, 2,665 hours.

TABLE II

AVERAGE NUMBER OF HOURS WORKED BY MANAGERS AND HELPERS PER YEAR

No. of elevators	Manager	First helper	Second helper
30	2,845	....	....
17	2,736	2,703	....
1	2,490	2,780	2,780
1	2,400	2,640	2,640

The data show that managers who have no helpers work more hours per year than those who have. Moreover, the greater the number of regular employes the smaller the number of hours worked by each. This may be partly because not all men begin work or leave the elevator at the same time but all are on hand whenever needed or when a considerable amount of grain is coming in. A greater number of regular men are employed, as a rule, where the volume of business is large. These facts, as will be seen later, tend to give a still smaller

number of hours of labor and management per bushel of grain handled in elevators of large volume. Elevators with the larger business seem to have not only shorter working days but also more systematic and businesslike managers.

The most important cause of this variation between the total hours employed and the actual hours spent at work is the differences in the adjustment of the labor to the business, including the sidelines and additional processes, as cleaning and mixing. The mechanical equipment of the house may also be a cause of variation. Occasionally an additional unit of labor is necessary in order to take care of additional business. If the labor is not fully utilized, labor costs may be higher than if the volume were a little larger or a little smaller.

The time necessary to load an average sized car of wheat or oats (Table III) illustrates the effect upon the labor requirement of the convenience and speed with which grain can be moved through the elevator. With wheat this depends upon the capacity of the elevating and weighing machinery, the kind of wagon or truck dump, and the kind of scale used in weighing grain as it goes out of the elevator. One elevator in the group had been a flat warehouse and was converted into a modern elevator. The cupola from which grain usually falls to railroad cars by gravity was so low that a direct loading spout could not be used. It was necessary to load from a low bin and to shovel the wheat back into the car. Other arrangements, as for weighing out, were equally as inconvenient. Elevators built more recently were so equipped that one man could handle at least three times the amount that two men were handling in this elevator.

TABLE III

TIME REQUIRED FOR LOADING A CARLOAD OF GRAIN

Hours	No. of elevators	
	Wheat	Oats
0–1	1	0
1–2	12	5
2–3	21	16
3–4	8	14
4–5	5	9
5–6	1	2
6–7	0	3
Total	48	49

The range for loading out wheat was from 40 minutes to 5 hours and for oats from 1 to 6 hours. The most frequent time for loading both wheat and oats was from 2 to 3 hours per car. An average carload of oats, however, contains almost twice as many bushels as a carload

of wheat,[4] so the same number of bushels of oats could usually be loaded in two-thirds or three-fourths the time required for wheat. Sometimes the shape of the pit prevents the oats running freely and slows up the rate at which it can be elevated. If the automatic weighing-out scale is not properly fitted to the capacity of the elevator machinery, it may not weigh the oats as fast as they are elevated. This makes it necessary to fill the buckets to a smaller proportion of their capacity, and the elevating and therefore the loading out are retarded. Any such poor adjustment of the capacity of units of equipment obviously increases the labor requirements.

As the storage capacity of the elevator increases, the capacity and completeness of the equipment increase, so that large elevators can perform all the processes in less time than small ones. Table IV gives the time required in elevators of different capacity to handle a carload of wheat or oats. With the exception of two elevators in the group handling from 40,000 to 50,000 bushels, the tendency for the time to decrease as the size of the elevator increases is pronounced for both wheat and oats. The time required to put wheat through elevators of 40,000 to 50,000 bushels capacity is unusually large because of the large amount cleaned by one.

TABLE IV

RELATION OF TIME NECESSARY TO HANDLE A CARLOAD OF WHEAT OR OATS TO VARIOUS STORAGE CAPACITIES, IN 49 ELEVATORS

Range in capacity	Average capacity	No. of elevators	Time required for all processes	
			Wheat	Oats
bu.	bu.		hr.	hr.
10,000–20,000	15,805	19	3.0	3.8
20,000–30,000	24,469	15	2.0	2.8
30,000–40,000	34,390	10	2.0	2.7
40,000–50,000	43,150	2	2.3	2.5
More than 50,000	58,417	3	1.1	1.6

Altho the saving in time may be significant, if the volume of business at a large elevator is not sufficient to warrant the use of the equipment, the cost per bushel may be higher than if more labor and cheaper equipment are used.

The time required for buying, receiving, and weighing was about the same per load irrespective of the size of the load or the kind of grain. Therefore the larger the average load the less time per bushel is required for these processes. The convenience of the scales (full capacity or recording beams rather than separate weights; an air dump instead

[4] The average amount of the various grains per car for the year of study is:

	bu.		bu.		bu.		bu.
Wheat	1,342	Barley	1,601	Rye	1,446	Flax	1,141
Oats	2,285	Buckwheat	1,451	Corn	1,428		

of a hand dump; and electricity instead of gasoline for power) reduces the time slightly with wagon loads. The kind of dump may make a still greater difference with truck loads. Variations in size of loads are due to some extent to the quality of the roads and the prevalence of trucks. More variations, however, appear to be due to the type of farming. In sections where small grain predominates, the loads are larger than in the timber country or where dairying is more important. Many small loads are marketed when the farmer is delivering cream or milk. These loads may be as small as 10 bushels, yet the time required for buying, weighing, and receiving may be equal to and often greater than that required for a regular load of 60 or more bushels delivered in the usual way. The difference in labor requirement can not be controlled by the manager.

All these factors, however, affect any analysis of the use of labor on the basis of actual hours worked, hence any comparisons of the hours necessary to handle a given amount of business have been made on the basis of the hours employes were at the elevator. The convenience of the elevator and variations in the amount and capacity of the equipment may affect the time required to handle a given amount of grain, but this is reflected in the total hours worked, and especially in the amount of extra labor employed.

In certain groups, however, there is considerable maladjustment between the hours required to handle a carload of grain and the actual number of hours per 1,000 bushels worked by the employes. Table V, for example, shows little correlation between the time needed for 1,000 bushels and that needed for a carload. The time required for handling a carload assumes that all processes are simultaneous. When cars are not available for shipping or the manager does not wish to sell, or when grain is coming in intermittently, this is not possible. Moreover, the receiving and the loading out must be handled separately when different grains are being received, unless the elevator has more than one leg and pit. If this is the case, the time given for handling grain per car (Tables IV and V) becomes the time for loading out a car, the total time for all processes being now about twice as great. The more interference there is with performing the operations simultaneously, the less the correlation between the total hours per 1,000 bushels and the time spent in handling a carload of grain. If the elevator is exceptionally well or very poorly equipped, the correlation will be higher than if the equipment is of average quality.

The time spent in caring for each 1,000 bushels of grain, including record keeping, varied from 8.9 to 86.3 hours. The elevator that required the least time was the best equipped mechanically and handled the largest volume. The elevator requiring 86.3 hours per 1,000 bushels

handled a relatively small volume, being one of the four lowest in point of total business as well as the most inconveniently equipped. The time required for handling a car in the former was 60 minutes for oats and 40 minutes for wheat; in the latter, 7 and 6 hours, respectively.

TABLE V

RELATION OF TIME FOR HANDLING A CARLOAD OF WHEAT TO TOTAL TIME PER 1,000 BUSHELS

Range in time for handling	No. of elevators	Average time per carload	Average time per 1,000 bushels
hr.		hr.	hr.
1.5–2	5	1.2	32.5
1 –1.5	7	1.5	50.7
2 –2.5	13	2.0	43.8
2.5–3	8	2.5	29.7
3 –3.5	8	3.1	46.8
More than 3.5	6	4.3	52.9

Table VI shows that a decrease in volume is accompanied by an increase in labor and management per 1,000 bushels. Whether the number of hours required is a result of the volume or of some other factor can not be stated. However, the change is not uniform throughout. In elevators with the largest volume a gradual increase in the hours of labor per 1,000 bushels accompanies a decrease in volume of business. For large elevators the rate of decrease is not marked, but when the volume is as low as 75,000 bushels the rate of increase in the number of hours is much greater for a unit change in volume and is still more for volumes lower than this. The relationship of these two factors is shown in Figure 5. It may be concluded from these data that economy of labor accompanies any increase in volume within the limits found in country elevators, but that these economies are most noticeable for increases under 100,000 bushels. They are still of considerable importance up to 300,000 bushels.

TABLE VI

RANGE IN HOURS OF LABOR AND MANAGEMENT PER 1,000 BUSHELS OF GRAIN

Range	No. of elevators in group	Average of group	Average amount handled
hr.		hr.	bu.
0–30	16	20.3	252,542
30–40	12	36.0	90,556
40–50	8	45.7	67,034
50–60	3	56.9	57,516
60–70	3	63.6	60,291
More than 70	7	81.1	35,819

The average decrease in hours necessary to handle 1,000 bushels of grain is given by 25,000-bushel increments in Table VII.

TABLE VII

RELATION OF VOLUME OF LABOR AND MANAGEMENT PER 1,000 BUSHELS OF GRAIN*

Volume	Labor and management	Decrease in labor and management for 25,000-bushel increase from last volume
bu.	hr.	hr.
25,000	88.2	....
50,000	54.7	33.5
75,000	41.3	13.4
100,000	33.9	7.4
125,000	29.1	4.8
150,000	26.6	2.5
175,000	23.1	3.5
200,000	21.0	2.1
225,000	19.4	1.6
250,000	18.0	1.4
275,000	16.9	1.1
300,000	15.9	1.0
325,000	15.0	0.9
350,000	14.3	0.7
375,000	13.6	0.7
425,000	12.5	1.1
450,000	12.0	0.5
475,000	11.6	0.4
500,000	11.2	0.4

* These data are based upon the curve of Figure 5, which is of the form $y = ax^b$ and which would give a straight line if plotted on double logarithmic paper. This curve makes it possible to use the logarithms of the values of the variables and obtain a straight line. In such form the data may be used for examination as to relationships by the Pearsonian method of correlation without the necessity of any curvilinear treatment.

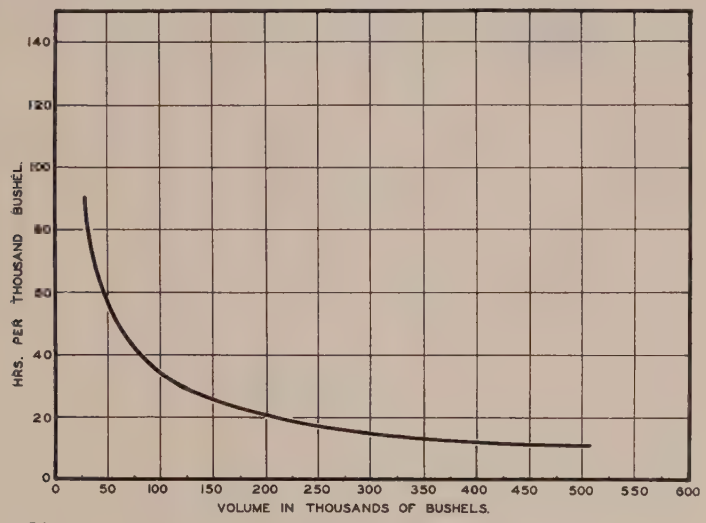

Fig. 5. Relation of Hours of Labor and Management per 1,000 Bushels to Volume of Business

From this table and Figure 5 it may be seen that the range per 1,000 bushels is from 88 hours for 25,000 bushels to 11 hours for 500,000 bushels. For an increase in volume from 25,000 to 50,000 bushels the decrease is about 34 hours; from 50,000 to 75,000 bushels, 13 hours; from 75,000 to 100,000 bushels, 7 hours; from 100,000 to 200,000 bushels, 13 hours; from 200,000 to 300,000 bushels, 5 hours; from 300,000 to 400,000 bushels, 3 hours; and from 400,000 to 500,000 bushels, 2 hours. Beyond this the hours of labor and management required continue to diminish at a variable decreasing rate.

The price paid for labor and management, like the amount used, varies widely between elevators and is dependent chiefly upon efficiency of labor and management and volume of business. Managers' salaries are also closely associated with operating profits. Large net profits are generally associated with large salaries, and vice versa. The cost of labor tends to increase with the volume of grain marketed. The extreme range was from 28 cents to 93 cents per hour, the ordinary range, from 33 cents to 65 cents. The relationship of volume to rate per hour is shown by the curve of Figure 6. With an increase in volume from 25,000 to 50,000 bushels the rate per hour increases from approximately 35 cents to 45 cents; from 50,000 to 75,000 bushels, from 45 cents to 52 cents; from 75,000 to 100,000 bushels, from 52 cents to 54 cents; that is, for a 75,000-bushel increase, the increase in rate per hour was 19 cents. For a similar increase from 100,000 to 175,000 bushels, the rate rose from 54 cents to 58 cents: at 200,000 bushels the rate was 58½ cents; at 300,000, 60½ cents; at 400,000, 62½ cents; and at 500,000, 65 cents.

The adjustment of labor to volume of business can not be made with as much nicety as the manager desires, because labor, not being divisible into small units, must be added or subtracted in units that are large in relation to increases or decreases in volume. If a unit of labor is considered as one man employed for a year, the unit is large. Even extra labor, hired frequently by the week or the month during the busy season, is used in large units. For this reason labor costs tend to increase or decrease continuously as volume decreases or increases, altho there is a considerable variation in this continuity because of maladjustment.

If it were possible to separate labor from management in this analysis, the cost per hour for labor would probably decline as the volume increases, because of the better utilization of labor and the more advantageous use of cheap labor for certain tasks, which is possible in a large enterprise. This is well illustrated by the wages of first and second helpers. Second helpers generally work for a lower wage than first helpers. This reduces the average rate paid by elevators that employ more than one helper.

The cost of management per hour, on the other hand, increases with the size of the business because of the higher salary and the smaller number of hours worked. Salaries paid to managers ranged from $1,080 to $2,400 per year and averaged $1,523. Table VIII shows that small salaries existed where the volume of grain was small and larger salaries where it was large. The unusually low salary paid by one of the two elevators handling an average of 218,000 bushels causes the average salary of this group to be out of line with those of the other groups. Otherwise, the salaries increased progressively as the volume of business increased.

TABLE VIII

SALARIES PAID TO ELEVATOR MANAGERS WITH VARYING VOLUME OF GRAIN

Volume	No. of elevators	Average salary
bu.		
38,070	11	$1,152
70,214	17	1,465
120,580	11	1,663
181,787	4	1,787
218,822	2	1,718
461,418	4	2,040
Average		
121,391	49	$1,523

A grouping of elevators on the basis of the number of helpers employed shows the same tendency. As the increase in number of helpers is highly correlated with increased volume, it is logical to associate the larger salary with larger volume of business rather than with some other factor, and also to look upon the increase in helpers as a result of the larger volume of business.

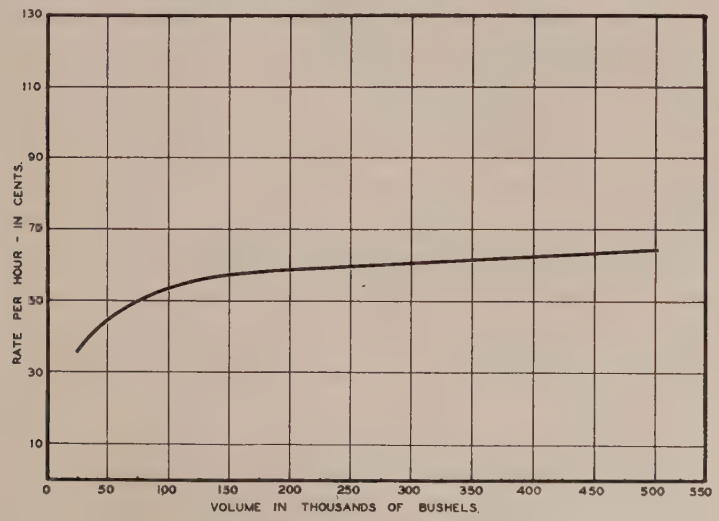

Fig. 6. Relation of Rate per Hour for Labor and Management to Volume

The total cost of labor and management ranged from $6.05 to $63.85 per 1,000 bushels, or from 0.6 to 8.4 cents per bushel, in the year the study was made. The average cost was $24.69 per 1,000 bushels, or 2.5 cents per bushel. The size of the business is an important factor affecting these costs. The relationship to volume of business is given in Figure 7.[5] It is significant that variations in the amount of grain handled under 100,000 bushels cause important differences in the cost of this element. The business with 50,000 bushels, for example, has costs 1.6 cents per bushel less than the one with 25,000 bushels in this one factor alone. The elevator handling 100,000 bushels has costs lower by approximately one cent per bushel than the one handling 50,000 bushels.

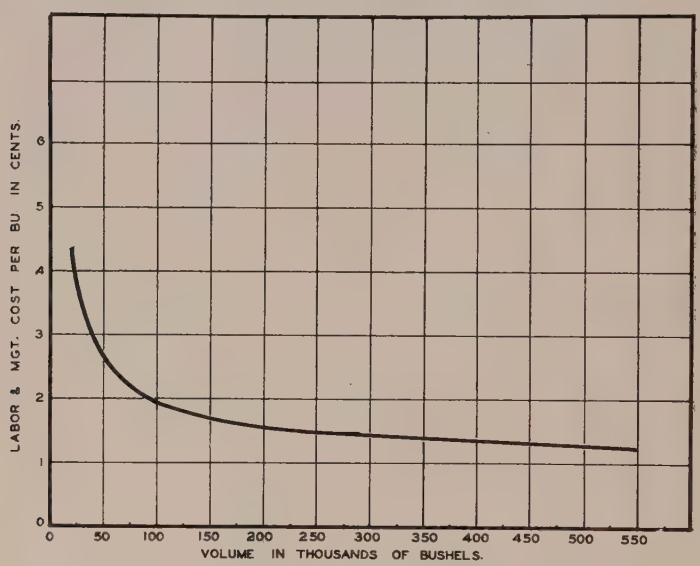

Fig. 7. Relation of Labor and Management Costs per Bushel to Volume

Variations in the size of business above 100,000 bushels, altho significant, have much less influence on costs. The difference between a 125,000 bushel business and a 100,000 bushel business, for example, is only 0.2 cent per bushel; between 150,000 and 125,000 bushels only 0.1 cent per bushel; between 175,000 and 150,000 bushels 0.09 cent per bushel; between 200,000 and 175,000 bushels 0.07 cent per bushel. Beyond this point, there is practically no economy from greater volume.

[5] An excellent fit is obtained when the values of y are calculated according to a curve of the formula $y = a + bx^{-1}$ by the method of least squares and these values plotted against the original values of x where x is the volume of grain handled and y the cost per bushel for each elevator. A linear relationship then exists when reciprocals of volume are used with costs per bushel. If analysis by the Pearsonian method is later desired, this function can be used without further manipulation or the introduction of the curvilinear method.

We may therefore conclude that variations in size of business up to 100,000 or even 125,000 bushels cause important differences in costs of labor and management. After that, size of business is less significant and is less important in explaining variations in costs of labor and management between elevators, because the higher salaries paid to managers offset the better utilization of labor.

TABLE IX

RANGE IN LABOR AND MANAGEMENT COSTS PER BUSHEL OF ALL GRAIN HANDLED

Group range	No. of elevators in group	Average cost per bushel	Average volume
cents		cents	bu.
0.50–1.25	6	0.8	359,958
1.25–2.00	17	1.6	115,906
2.00–2.75	10	2.2	86,318
2.75–3.50	8	3.0	62,852
3.50–4.25	5	3.7	65,841
More than 4.25	3	5.2	40,936

Graphic presentations of these relationships (Figs. 5, 6, and 7) show that variations in the amount of labor and management are more important in explaining variations in costs between elevators of different size than are variations in the rate paid. When volume of business is eliminated as a factor causing variations in cost, differences in the amount of labor and management cause approximately three-fourths of the variations in labor and management costs, and differences in the rate paid, one-fourth.[6] Eleator managers are more skillful in fixing a rate of wages than in planning for the amount of labor to be employed.

The amount of labor and management per 1,000 bushels is influenced by several factors, altho with available data only the item of equip-

[6] A multiple correlation with the cost per 1,000 bushels for labor and management as the dependent variable and hours per 1,000 bushels and rate per hour as the independent variables gives a correlation of 0.998.

The percentage of variations in costs accounted for by the independent variables is expressed by means of coefficients of determination. The square of coefficient of multiple correlation measures the percentage of total variation in the dependent variable that can be accounted for by variations in the independent variables where the standard deviation is used as the measure of variation and variability is defined by the square of the standard deviation. The coefficients of determination for the separate independent variables were obtained by multiplying the coefficients of total correlation between the dependent and independent variables by their respective net regression coefficients. The sum of these products is the square of the coefficient of multiple correlation; and each individual product is the coefficient of determination of the respective independent variable, derived directly from the least-square treatment and without joint terms.

The total squared variability with cost per 1,000 bushels for labor and management as the dependent variable and hours per 1,000 bushels and rate per hour as independent variables is 0.998. The proportion of the variability attributable to each of the independent variables is as follows:

	Per cent determination
Hours per 1,000 bushels	75.3
Rate per hour	24.5
Total	99.8

ment can be analyzed. Table X indicates, however, that only 0.5 per cent of the variations in labor and management costs can be attributed to this factor—much less than is often supposed.[7] This is probably accounted for by the comparatively uniform type of equipment installed in elevators, which does not allow much latitude in the hiring of labor and management so far as this factor is concerned. Mention should again be made of the fact that volume is eliminated in this comparison of costs and that the figures in Table X indicate the relative importance of the different factors for elevators marketing similar quantities of grain.

TABLE X

RELATIVE IMPORTANCE OF SOME FACTORS CAUSING VARIATIONS IN LABOR AND MANAGEMENT COSTS

Factors causing variation	Per cent of total variation
Hours per 1,000 bushels	74.9
Equipment cost per 1,000 bushels	0.5
Rate paid per hour	24.6
Total	100.0

To employ the proper amount of labor at the right rate is therefore an important management problem. This may be illustrated from the experience of these elevators. Seven of the 30 elevators employing only one person handled volumes of grain ranging from 106,000 to 200,000 bushels at an average cost for labor and management of 1.5 cents per bushel, as compared with the average of 2.3 cents for the 49 elevators included in the study. Four of the elevators having one helper handled less than 100,000 bushels, the volumes being 53,000, 74,000, 82,000, and 83,000 bushels. Costs for labor and management per bushel were 4.6, 2.3, 3.0, and 1.5 cents, respectively. The elevator having the lowest volume was situated in a region where in other years the volume was much higher. Owing to a poor crop, the volume was reduced yet the helper was retained. It is questionable whether, even in years when the production was greater, the volume was large enough to warrant the employment of a helper. In the second elevator mentioned, a helper was probably necessary because of inconvenient construction and arrangement. Its location in a region where the average load was small made it still more difficult to handle a given

[7] If the cost per bushel for equipment is taken as a measure of the completeness of the equipment, it may be included in the correlation as an independent variable and its net effect determined and expressed through its coefficient of determination. As the determination of cost per 1,000 bushels for labor and management was practically complete, the multiple correlation coefficient and its corresponding coefficient of total determination can not be appreciably increased. The coefficients of determination for the respective independent variables will change, as the net effect of equipment has now been taken out.

amount of grain with the same amount of labor as in communities where the average load was larger. Both the other elevators could easily have dispensed with the second man without over-working the manager. The volume had not been sufficient for several years to warrant the employment of more than one man. Financial difficulties in the last elevator forced a change of managers in 1924-25. It is now being operated by the manager with practically no extra labor and no visible decrease in volume.

From a study of these data we can reasonably conclude that in an elevator doing the usual small sideline business (principally fuel and feed), and a limited amount of cleaning, the employment of a helper is not justified at a volume of less than 100,000 bushels. If the elevator is well equipped and is located in a region where there may be more than one peak in grain receipts, the manager may market up to 200,000 bushels with little extra labor. It is necessary in almost any elevator to employ some extra labor during the period of heaviest receipts.

Few elevators in Minnesota require more than one helper unless the sideline business is large. Elevators in this study, as previously pointed out, handled up to 500,000 bushels with one regular helper. Two elevators hired more than one additional man, one of them handling 703,000 bushels for the crop year 1923-24. This elevator, with the same regular help, handled over 1,000,000 bushels in a previous year, the largest volume in its experience. The other elevator, having three regular helpers, was located in a medium sized town, carried on an extensive fuel, flour, seed, and feed business, extended credit, and made deliveries. Only three elevators used the helper practically full time as a bookkeeper, altho his work often involved selling merchandise and weighing in grain. The last two elevators mentioned that had more than one helper employed bookkeepers. The elevator employing only a bookkeeper in addition to the manager also sold merchandise for credit.

Keeping records is generally the work of the manager unless a bookkeeper is employed. Occasionally the secretary of the board or the local banker keeps the accounts. About $25 a month is paid for this service.

The time spent in keeping records varies widely from elevator to elevator and depends chiefly upon the kind of records kept, the volume of business, and the amount of time the manager has to spend on the records. Managers having no helpers spent an average of 282 hours per year in keeping records of the grain business and 43 hours for records on sidelines. Those having one helper spent an average of 395 hours on grain and 82 hours on sidelines. The three elevators employing full-time bookkeepers spent about equal time on grains and sidelines and an average of 1,204 hours on both. The time necessary to look

after records of the sidelines when sales are for cash is relatively small, averaging about one-fifth of the total. Elevators employing a full-time bookkeeper spend much more time on the records for a given volume of grain but they save in auditing expense if they have an audit by a public accountant. In some instances the audit is dispensed with on this account. More time is spent per 100 bushels of grain when a full-time bookkeeper is employed, but the superiority of the records makes it economical even if the cost is higher per unit of grain handled.

Table XI, giving the average volume of grain and the time spent by the various groups of elevators (the three with full-time bookkeepers having been omitted), shows that more time is spent in keeping records by elevators of large volume, altho the relationship between volume and time spent is not entirely consistent. The time spent seems often to be the result of having more time free from other work. The manager who has a helper generally gives more attention to the records regardless of the volume of grain. For this reason the relationship between volume and the time given to records is less regular between elevators of large volume with one or more helpers and those of smaller volume with no helpers and little temporary labor.

TABLE XI

HOURS OF LABOR SPENT IN RECORD KEEPING AND CORRESPONDENCE FOR ELEVATORS WITH VARIOUS VOLUMES

Range in volume	No. of elevators	Labor per year on grain	Labor per year on sidelines
bu.		hr.	hr.
0– 50,000	11	235	42
50,000–100,000	16	290	45
100,000–150,000	10	406	44
150,000–200,000	4	231	116
200,000–250,000	2	405	53
More than 250,000	3	380	88

Building and Site

Utilization of Storage Space

The utilization of storage space is an important factor in determining building costs. The size of an elevator is ordinarily expressed in terms of its capacity, that is, the number of bushels of grain that it will accommodate at a given time. Its utilization is measured by the turnover, or the number of bushels handled for each bushel of capacity.

The smallest elevator in the group studied has a capacity of 10,500 bushels and the largest one of 66,000 bushels. Table XII shows that elevators of large capacity are likely to be located where the volume of business is greater, altho there are important variations from this tendency. For example, the elevator having the largest capacity was

among the four lowest in volume of grain handled. The size of this elevator was well adapted to the conditions of the shipping point at the time it was built, but changes in the type of farming, increases in potato acreage and in dairying, and the subsequent locating of other elevators at the same point have made it a misfit. This elevator, like some others, would be differently constructed if it were rebuilt.

TABLE XII

RELATION OF ELEVATOR CAPACITY TO VOLUME OF GRAIN HANDLED

Range in capacity	Elevators in group		Average capacity	Average volume	Volume per bu. capacity	Building expense per bu. capacity
	Number	Cumulative, % of total				
bu.			bu.	bu.	bu.	cents
10,500–20,000....	19	39	15,805	77,434	4.8	4.2
20,000–30,000....	15	70	24,469	112,875	4.5	3.5
30,000–40,000....	10	91	34,390	128,122	3.7	3.3
40,000–50,000....	2	95	43,150	318,311	7.3	2.4
50,000–60,000....	2	99	54,625	415,466	7.7	2.7
More than 60,000....	1	100	66,000	36,022	0 6	3.9
Average			29,975	121,391	4.7	3.7

Nineteen elevators, or 39 per cent, had capacities under 20,000 bushels; 70 per cent under 30,000 bushels; 21 per cent between 30,000 and 40,000 bushels; and only 5 per cent more than 40,000 bushels. It is significant that those with more than 40,000 bushels capacity use storage space more effectively than smaller ones. The one elevator in the last group is again the exception. Moreover, among the elevators of less than 40,000 bushels, those with the smallest capacity have the largest turnover, the group of 10,500 to 20,000 bushels handling 4.8 bushels for each bushel of capacity as against 3.7 bushels for the group of 30,000 to 40,000 bushels. The extreme range in turnover was from 1.3 to 17.5 for individual elevators. The ordinary range is from 1.5 to 10.

Annual building expense per bushel of storage capacity likewise decreases as the size of the elevator increases. This is largely because the cost of construction per bushel of storage space is more in a small elevator than in a larger one. The last two groups are exceptions, as shown by Table XII. The reason for the high cost of the elevator in the largest group has been mentioned. The tendency of the group with capacities from 50,000 to 60,000 bushels is out of line with that of the previous group because of the large expense of one elevator. The annual building expense of the two elevators in this group was 2.3 and 3.1 cents per bushel of storage space. The elevator with the highest cost was exceptionally well constructed and was ironclad. This increased the annual expense. If there were as many elevators in the last groups as in the first, the expense per bushel would be lower.

When the elevators are grouped according to volume, the increase in the utilization of space with increase in the volume of business is more consistent. Figure 8 shows the relationship graphically.[8] The turnover increases almost at the same rate for similar increases in volume of business in elevators of all volumes, the tendency being for the rate of increase to decline slightly between those of large volume. For

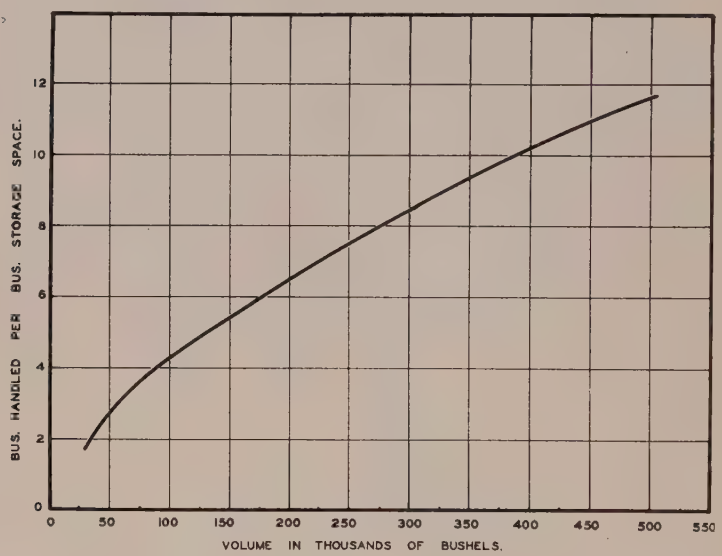

Fig. 8. Relation of Utilization of Storage Space to Volume
The turnover of capacity increases as volume increases.

example, an increase from 30,000 to 60,000 bushels in volume handled results in an increase of 1.2 bushels in the amount handled for each bushel of capacity. A similar increase from 120,000 to 150,000 bushels results in an increase of 1.0 bushel per bushel of storage capacity; an increase from 420,000 to 450,000 bushels increases this amount 0.6 bushel, that is, the increase in volume handled per bushel of capacity for each 1,000 bushels from 30,000 to 60,000 is approximately 0.04 bushel, and for volumes between 420,000 and 450,000 bushels about 0.02 bushel.

This analysis indicates that there is a close relationship between volume and utilization of capacity but it does not indicate the relative importance of volume and capacity as factors affecting variations in utilization. A statistical analysis shows, however, that 92 per cent of the variability is due to differences in volume and 8 per cent to differences

[8] A curve of the form $y = ax^b$ for calculating values of y or utilization of storage space, where x is the independent variable or volume, gives a good fit.

in capacity. This means that there is a relatively greater variation in volume than in capacity between elevators. These data should not be interpreted as indicating that there is a better adjustment of capacity to volume than of volume to capacity.

These data, as well as all data used in the study, are based on one year, 1923-24, and some maladjustments of volume to capacity occurring in this year may be corrected in another year. Crop conditions were similar throughout the region, so it is believed the relationship would not be greatly changed when crop yields average higher or lower than for this year.

Annual Site Costs

Few farmers' co-operative elevators own the site upon which the elevator is located. Only two of the 49 under consideration owned their sites. The sites are usually owned by the railroad serving the elevators. The minimum rental charged was from $12.50 to $15 for 60 front feet or less, depending upon the railroad. For a frontage greater than the minimum the annual charge is 20 cents per linear foot. This usually makes the total rental charge from $15 to $25 per year. More often the sites on which sideline buildings are located are the property of the elevator owners, but not many own these. Coal sheds or other buildings may raise the charge if they are large or numerous. In this study the rental expense of the site has been included with the building expense because it is so small an item. Elevators that owned their site were charged 4 per cent interest on the estimated conservative sale value of the site. The taxes were added to obtain the annual site charges comparable to rental. All other elevators were charged the annual rental paid. The division of expense between grain and sideline enterprises was made on the basis of linear feet frontage occupied by each. The site rental is approximately the same per linear foot from elevator to elevator, so whatever variations exist are due principally to differences in frontage.

Building Costs

Building costs, as reckoned in this study, are a composite of interest, depreciation, maintenance, insurance, and taxes. Costs for buildings were calculated on the basis of appraisals made, as previously explained.

Interest.—Interest is considered as a cost. As accurate costs are not wanted for costs' sake, it is desirable that the costs include any element in which there is a variation that affects the efficiency of the organization. At the same time, variations in age of building and in price level, or the cost when the elevator was constructed, should be eliminated in order to place the elevators on a comparable basis. Interest has therefore been calculated on the basis of one-half the replace-

ment value. This method obtains an annual cost figure for buildings that approximates the economic costs.

The rate used in the calculation of interest was the most usual rate paid in the section for loans on elevator buildings and equipment, if no such indebtedness actually existed. On this basis the average annual interest charge on buildings, for the 49 elevators, was $352. This constituted 39.6 per cent of the total annual expense for buildings and site, or about two-fifths the total building cost.

Depreciation.—The rate of depreciation varies according to the construction and condition of buildings, and the care they receive. The rate at which it had taken place was a matter of judgment in each case. This method undoubtedly more nearly approximates the actual cost of depreciation than the use of a constant annual rate. As many of the elevators were of about the same construction and were cared for in the same way, the rate was the same for a large number. The most usual rate was 3 per cent. Depreciation varied more for sideline buildings than for elevator buildings, owing principally to variations in type of construction.

Since many of the elevators were built there has been a decline in the value of their use, owing to changes in type of farming in the region and also in type of elevator construction. The latter is much the less significant of the two. The demand for a 60,000 bushel elevator, for example, may have declined, so that a 20,000 bushel elevator is adequate. Under such circumstances it may be questioned whether depreciation for wear and tear should be charged on the basis of the replacement value of the 60,000 bushel or the 20,000 bushel elevator. As the discovery of reasons for variations in efficiency was one of the purposes of this study, to calculate depreciation on the basis of the most suitable size of house would eliminate a cause of variation in cost over which the managers of an elevator have control. Depreciation at the determined rate was therefore calculated on the basis of the replacement value of the elevator as it stood. The average depreciation for elevators studied was $264—29.7 per cent of the total annual building and site cost.

Maintenance.—This includes repairs and upkeep of buildings as shown by the audit report. The proper annual charge should be determined by dividing the total cost of repairs and renewals by the number of years they will be effective. This method of allocation is possible with large items of expense but is scarcely feasible with small and miscellaneous items. Any large item, as painting, for which detailed information could be obtained, was therefore prorated over its probable useful life and not all charged as an expense for the year in which it was a cash expenditure.

Insurance.—Insurance was charged at the annual rate paid for the given year. For some purposes the cost of insurance should not

be reckoned the same from year to year. For example, the building decreases in value as it becomes older, and the amount of insurance and the premiums may therefore decline. However, the amount of insurance actually carried is frequently not the maximum possible. In the first place the amount that different insurance companies write differs appreciably. In 1924 a new elevator was built at one of the stations at an actual cost of $15,000. The maximum insurance that one conservative company would write was $8,000. Another company insured it for practically the cost of construction. In the second place, the financial condition of the elevator may determine to a considerable extent the amount for which a company will insure it. However, these causes of variation in costs should not be eliminated. For that reason, as well as because it is difficult to find out what the total insurance costs are during the life of the building, the annual insurance expense was taken as the cost of insurance. If an insurance company does not carry all the risks for a given premium, it may be contended that part of the hazard must be borne by the elevator owners, that it thus exists as a cost and should consequently be considered a cost of operation. This may be true, but it is impossible to determine the cost of carrying the risk.

Moreover, variations in type of power, fire protection, care with regard to dust, proximity to other buildings, construction, and the powerhouse have an important bearing upon the rate paid for insurance. The moral rating of the manager and the financial condition of the elevator, altho they do not directly affect insurance rates, frequently force insurance with companies that write risks of a doubtful character and at a higher rate. As all these factors affect the efficiency of operation, they constitute additional reasons for considering the insurance cost as the annual expenditure for that item.

Insurance was carried in both mutual and stock companies. The average annual payment was $81 per elevator—a little more than 9 per cent of the total building and site cost.

Taxes.—If tax rates and the original valuation remained unchanged except for decreases in valuation due to depreciation, the annual tax expense would decline as the buildings depreciate. In that case the annual tax cost should be considered the same throughout the life of the building just as is the interest charge previously referred to. Assessed valuations, however, deviate from actual valuations to a marked degree and from year to year, as do the rates of taxation. These variations make it impractical to make the same annual charge for taxes throughout the life of the building. Therefore the actual amount paid or accrued was made the tax charge. In Minnesota the assessed valuation is 40 per cent of the actual valuation, as determined

by the assessor. The rates vary between local tax units. The average tax paid in 1924 was $104 per elevator, or 11.7 per cent of the total building and site cost.

It is apparent from this discussion that the cost of construction is an important factor in explaining the annual building expense of local elevators. But the cost of construction varies between elevators for two reasons: (1) Elevators vary in capacity, (2) the type of construction varies.

Figure 9 shows, for example, that the cost of construction per bushel of storage capacity is highest for the smaller elevators. But the rate of decrease in cost is not constant for increases in capacity, the decreases being greater for each 1,000-bushel increase between the smaller elevators than between the larger ones. The calculations of construction cost given in Figure 9 were made on the basis of frame-cribbed elevators in the Red River Valley in 1924, with Fargo, North Dakota, as the basic point for freight on materials. The data were

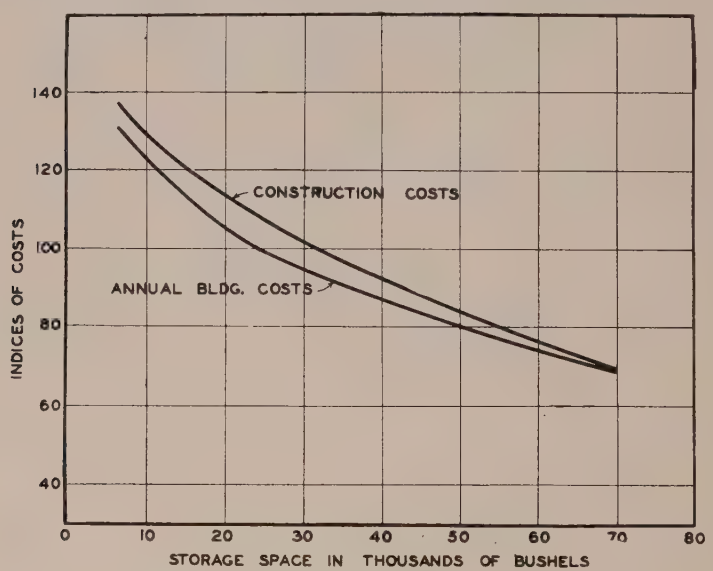

Fig. 9. Relation of Construction Costs and Annual Building Costs to Capacity of Elevators

Annual building and construction costs decrease per unit of capacity as the capacity increases.

obtained from the largest elevator construction companies in Minneapolis, which operate in Minnesota, Iowa, Montana, North Dakota, and South Dakota. Thirty-six of the elevators in this study had capacities of 30,000 bushels or less. The per-bushel construction cost for a 30,000 bushel elevator has therefore been taken as 100, and costs

for higher or lower capacities are determined and expressed in relation to this. Altho these cost data are for a single year, the relationship between large and small elevators had not changed to any considerable extent for several years. The principal change in cost of any construction material has probably been in the iron used to make the structure ironclad, and the cost of ironclad elevators has been omitted from the calculations upon which the upper curve of Figure 9 is based.

Economy in cost of construction per bushel of storage space is relatively less after a storage capacity of 30,000 bushels is reached. Up to this point, as indicated in Figure 9, the construction cost of storage space has appreciably more influence on annual building expense than with a larger elevator. Thus, it may be more desirable to have one 25,000 or 30,000 bushel building at a station, instead of two 15,000 bushel buildings, other things being the same. At several stations farmers' co-operatives have two buildings. Usually these have been constructed at different times to meet the growing requirements of increased business. However, one organization included in this study had two small elevators at the same shipping point destroyed by fire a few years ago and immediately reconstructed both on the old sites, when costs, from a building standpoint, regardless of any saving in equipment, would have been reduced by the construction of one larger building. The manager of this elevator volunteered the opinion that labor costs would have been reduced and that two cars could have been loaded more quickly with one elevator than with two.

Local elevators are more highly standardized as regards type of construction and materials used than most other types of local marketing agencies. This is probably due to the early development of the business and the building of elevators by a relatively small number of construction companies. There are, nevertheless, variations in materials and types of construction that cause important differences in costs.

All the elevators of this study were frame and of cribbed construction, that is, the walls and the bins were formed by placing timbers, usually 2x6 inches, flat on each other. Eighty per cent of the buildings were covered with wood; the other 20 per cent, with iron. This represents approximately 90 per cent of all Minnesota elevators, only a relatively small number being frame structures or brick and concrete.

The space occupied by office, powerhouse, or driveway was greater for the larger sized elevators. However, in a few cases it had no definite relation to the size of the building. Little attention seems to have been given, in some instances, to planning these additional parts when the elevator was constructed. If this had been done, some economy might have been effected. The cost of remodeling a building is

prohibitive for most companies. Sometimes elevators are constructed and arranged primarily with lower insurance rates in view.

The number, arrangement, and construction of bins, also, is highly standardized. The number of bins varies directly with capacity, altho some elevators have a relatively large number of bins for mixing, cleaning, and otherwise conditioning grain. Other elevators are constructed primarily to market large amounts of grain with the least possible handling, hence have relatively few bins. The number of bins ranged from 9 to 23, with 11 as the most frequent number. Seventy-five per cent of the elevators had from 11 to 13 bins.

Figure 9 also indicates that there is a close relation between the cost of construction and the annual building expense. This is to be expected. Interest, depreciation, insurance, and the other principal items in building expense are dependent chiefly on valuations. On the other hand, there is some divergence between the annual building costs, as calculated in this study and indicated by the lower curve in Figure 9, and the construction costs as obtained from elevator construction companies. This is partly because the elevators are constructed of different materials and with different arrangement of bins, some elevators being ironclad and others being constructed entirely of lumber; and partly because some such items as maintenance and insurance do not vary directly with the valuations, as will be explained later.

An analysis of the annual building costs of individual elevators shows an even greater variation from construction costs than the average given in Figure 9. We may nevertheless reasonably conclude that the cost of construction is an important factor in building costs.

Total Building and Site Costs

The average amounts of the various items of annual building and site expense per elevator and per bushel and the percentage that each is of the total are presented in Table XIII. Interest, constituting 39.6 per cent, and depreciation, 29.7 per cent, make up 69.3 per cent of the total. Taxes, the next largest item, form 11.7 per cent; insurance, maintenance, and site rental are 9.1, 7.0, and 2.9 per cent, respectively. The low site cost is largely due to the fact that the sites were rented. Where sites were owned, even at an interest charge of 4 per cent on the valuation, the costs were heavier. In most cases it was cheaper to rent the site than to own it. The average building and site cost per bushel is 0.74 cent, as compared with an average labor and management cost of 2.5 cents per bushel.

TABLE XIII

DIVISION OF ANNUAL BUILDING AND SITE COSTS OF 49 ELEVATORS

Item	Average costs		Per cent of total building costs
	Per elevator	Per bushel	
		cent	
Interest	$352	0.29	39.6
Depreciation	264	.22	29.7
Maintenance	82	.05	7.0
Insurance	81	.07	9.1
Taxes	104	.09	11.7
Site rental	26	.02	2.9
Total	$889	0.74	100.0

The relation of building and site costs to volume of business is indicated in Table XIV. The reader will recall that costs increase as the size of the building increases. As the size of the building is highly correlated with volume, total costs tend to increase with volume. Interest and depreciation increase more nearly directly with volume than any other costs. The lowest interest charge for any group is found in the volume ranges from 50,000 to 100,000 bushels, because the average capacity is smaller in this group than in any other. The average size of the first group, for example, is appreciably influenced by a few large elevators that are misfits for their stations, as well as by the fact that a larger percentage of the elevators are ironclad. This, in turn, results in higher valuations. Variations in interest and depreciation between the other groups come about mainly from differences in type and materials of construction. As interest is chiefly dependent on the valuation of the building, variations in valuation result in variations in interest. The annual depreciation is somewhat similarly governed.

TABLE XIV

DIVISION OF BUILDING AND SITE COSTS FOR ELEVATORS WITH VARIOUS VOLUMES

Range in volume	Average volume	No. of elevators	Interest	Depreciation	Maintenance	Insurance	Taxes	Site	Total
bu.	bu.								
0– 50,000	38,070	11	$337	$253	$ 3	$ 67	$ 75	$18	$ 753
50,000–100,000	70,214	17	307	230	72	70	118	28	825
100,000–150,000	120.580	11	386	290	121	115	109	24	1,045
150,000–200,000	181,514	4	323	243	50	59	88	25	788
200,000–250,000	218,822	2	371	378	17	69	101	42	878
More than 250,000	461,418	4	515	386	49	102	129	27	1,206
Average	121,391		$352	$264	$ 62	$ 81	$106	$26	$ 889

Maintenance depends on both the need for repairs and the availability of funds for making them. If there has been an operating deficit for several years, the amount spent for repairs is low. The rate of depreciation may increase from the lack of such repairs as painting, which further exposes the buildings to the weather. For these reasons there is still more variation in the expense items.

Insurance and taxes show still less correlation with size of building, valuation, and attending volume, owing to several factors. Variation in insurance rates, depending on the probability of loss from fire, is one reason. Variations in rates between companies and differences in the amount of insurance desired by owners cause much variation in the costs as here calculated. There may also be a difference in valuation of property among the insurance companies, due chiefly to the way in which they regard obsolescence, which affects the maximum amount of insurance that can be carried. Taxes fail to follow any definite trend for the different groups, largely because of differences in tax rates, but somewhat because of variations in assessors' valuations.

TABLE XV

Building Costs per Bushel of Storage Capacity

Group range	No. in group	Average cost per bushel storage capacity	Average volume for group
cents		cents	bu.
Less than 2.5	9	2.4	149,677
2.5–3.0	5	2.8	91,229
3.0–3.5	12	3.3	190,062
3.5–4.0	7	3.8	85,408
4.0–4.5	9	4.2	79,921
More than 4.5	7	5.7	78,122
Average	49	3.5	121,391

When building costs are expressed as a percentage of the total, the items follow rather closely the absolute figures in the order of importance. Interest and depreciation form a slightly larger proportion for the elevators handling a small volume than for those of greater volume. In the lowest volume group they form approximately 78 per cent of the total as compared with an average of approximately 60 per cent for all elevators. The two groups handling 50,000 to 100,000 bushels and 100,000 to 150,000 bushels have lower interest and depreciation costs than the average; the other groups have higher costs.

The item next in importance below interest and depreciation is taxes, forming 11.7 per cent of the total cost, with insurance, maintenance, and site making up 9.1, 7.0, and 2.9 per cent, respectively. The greatest range in the percentage of cost for any item as between elevators of different volume is in maintenance—from less than 0.5 per

cent to almost 12 per cent. As would be expected, the lowest expenditure for maintenance was on elevators of small volume, some of which were weak financially.

The extreme range in building and site expense, when expressed in cents per bushel of capacity, is from 2.3 to 8.4 cents. When the elevators are grouped according to costs, as in Table XV, the average for the groups ranges from 2.4 to 5.7 cents. Moreover, the volume accompanying this grouping decreases as the annual costs per bushel of capacity increase. This means that elevators with high costs per bushel of storage space are usually of small volume and can often least easily withstand heavy costs. Many elevators handling a small volume have a small storage space. This is the most important cause of the relationship. The average annual cost was 3.5 cents per bushel of storage capacity. The building cost per bushel of grain handled is dependent on both this and the number of bushels handled per bushel of storage capacity (Table XII and Figs. 9 and 10).

The extreme range in building and site costs per bushel handled was from 0.2 to 3.5 cents, and the ordinary range from 0.3 to 3.0 cents. The distribution of elevators according to range in costs is given in

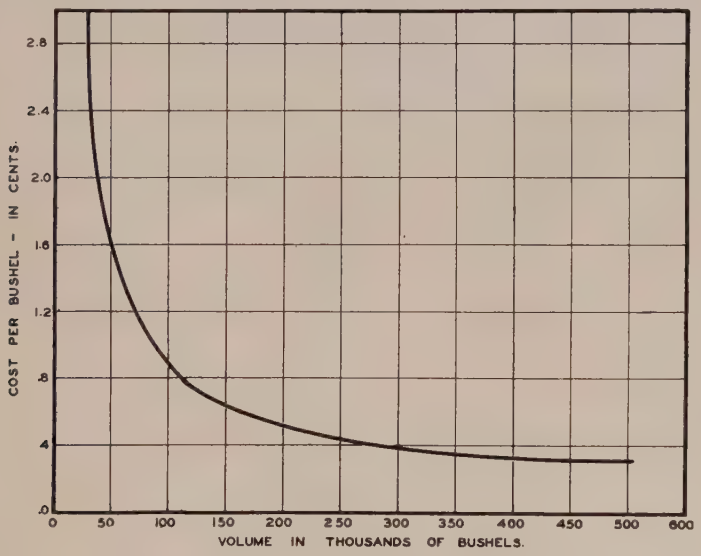

Fig. 10. Relation of Annual Building and Site Costs per Bushel to Volume This curve is best fitted to the data when $y = a - b^{-1}$.

Table XVI. The average cost, 0.74 cent per bushel, is indicated in Table XIII, where the average is weighted by the number of bushels for each elevator. This method of weighting gives an important influence to elevators with large volume and low costs. On the other hand, a simple average of these costs, as in Table XVI, is 1.15 cents

per bushel. As 24 elevators have costs under one cent, and 24 from one to 3 cents, this average is the more significant because it better describes what costs were at different elevators.

TABLE XVI

ANNUAL BUILDING COSTS PER BUSHEL OF GRAIN HANDLED FOR 49 ELEVATORS

Range	No. in group	Average of group	Average per elevator	Average volume per group
cents		cents		bu.
0–0.5	10	0.35	$ 886	290,176
0.5–1.0	14	0.76	799	105,205
1.0–1.5	15	1.19	902	76,798
1.5–2.0	2	1.64	716	43,055
2.0–2.5	3	2.29	1,031	47,791
More than 2.5	5	2.85	1,087	38,419
Average	49	1.15	$ 889	126,891

The relation between volume and annual building and site costs per bushel is indicated much more strikingly when presented graphically as in Figure 10, which shows that costs decrease rapidly with increased business at low volumes. For elevators handling 25,000 bushels the cost per bushel was 3 cents; for those marketing 50,000 bushels, 1.6 cents; a variation in cost of 1.4 cents. A variation from 50,000 to 75,000 bushels resulted in a decrease in cost from 1.6 to 1.1 cents, the difference being less than half that of elevators handling from 25,000 to 50,000 bushels. The cost at a volume of 100,000 bushels was approximately 0.9 cent; at 150,000, 0.64; at 200,000, 0.52; at 300,000, 0.40; at 400,000, 0.34; and at 500,000, 0.30. Above 100,000 bushels the variation in cost declines appreciably with variations in volume, and above 200,000 bushels the decrease in annual building expense with increases in volume becomes smaller and smaller, the decrease in cost per bushel being only 0.2 cent from 200,000 to 500,000 bushels.

The foregoing data show that the largest single factor influencing the annual building and site cost is the volume of grain handled. Variations from elevator to elevator are small as compared with those caused by differences in volume.

Equipment

The variation in equipment between elevators, even of the same storage capacity, is relatively much greater than the difference in size of buildings. Dumps, cleaners, power equipment, driveway, and scales may be very different, as may also the price paid.

The method of calculating cost of equipment is the same as for buildings. Interest was calculated at the same rate and on one-half the replacement valuation. This method does not involve any information

as to the length of life of the equipment. The valuations used were previously described. Depreciation, likewise, was calculated from these valuations.

Depreciation is more variable for equipment than for buildings. The amount of use to which an elevator building is subjected increases only to a small extent the rate of depreciation. Under these circumstances depreciation is largely a fixed factor and is proportional to time rather than to use. On the other hand, well cared for equipment depreciates little with time. Its depreciation is mainly with use and may therefore be considered more variable. The rate at which the cost for depreciation was calculated was therefore based on the history of the machine and the experience of equipment and insurance companies. The usual rate was 5 per cent.

Maintenance, as calculated here, is practically the cost of materials and labor for repairs and renewals. The cost of labor for oiling and cleaning the equipment, which is very small, has not been included because of the difficulty of obtaining accurate figures.

Equipment expense per elevator (see Table XVII) averaged $422 for the year. Depreciation is the largest single item, with interest second, the two constituting 74 per cent of the total. Taxes and insurance follow in the order named. The average cost per bushel of grain handled for all elevators is only about 0.33 cent.[9]

TABLE XVII

AVERAGE EQUIPMENT EXPENSE OF 49 ELEVATORS

Item of expense	Per elevator	Per bushel handled	Per cent of total expense
		cents	
Interest	$113	0.09	26.8
Depreciation	198	.18	46.9
Maintenance	51	.04	12.1
Insurance	26	.02	6.2
Taxes	34	.03	8.0
Total	$422	0.34	100.0

The greatest variation is in the cost of maintenance, which is practically all for repairs (see Table XVIII). The percentage that each item is of the total cost of equipment is constant for elevators of different volumes and is well represented by the average for the different groups. However, the total cost per bushel continues to decrease with increased business.

[9] The simple average cost, on the other hand, is 0.54 cent per bushel and probably more nearly represents the most probable cost for any elevator taken at random than a weighted average. Only 12 elevators have an equipment cost lower than 0.33 cent, the weighted average cost.

TABLE XVIII

RELATION OF VOLUME TO EQUIPMENT COST

Range in volume	Average volume	No. of elevators	Cost per elevator						Average cost per bushel
			Interest	Depreciation	Maintenance	Insurance	Taxes	Total	
bu.	bu.								cents
Under 50,000	38,070	11	$102	$179	$39	$21	$22	$363	0.95
50,000–100,000	70,214	17	99	174	26	21	34	354	.50
100,000–150,000	120,580	11	116	203	94	39	38	490	.41
150,000–200,000	181,514	4	135	237	37	25	42	476	.26
200,000–250,000	218,422	2	118	206	75	20	34	453	.21
More than 250,000	461,418	4	166	291	79	32	41	609	.13
Average	121,391		$113	$198	$51	$26	$34	$433	

The decrease in annual cost of equipment per bushel that accompanies increased volume, as indicated in Figure 11, is similar to that for buildings. From about 1.4 cents per bushel at a volume of 25,000 bushels the cost decreases markedly up to 100,000 bushels, at which

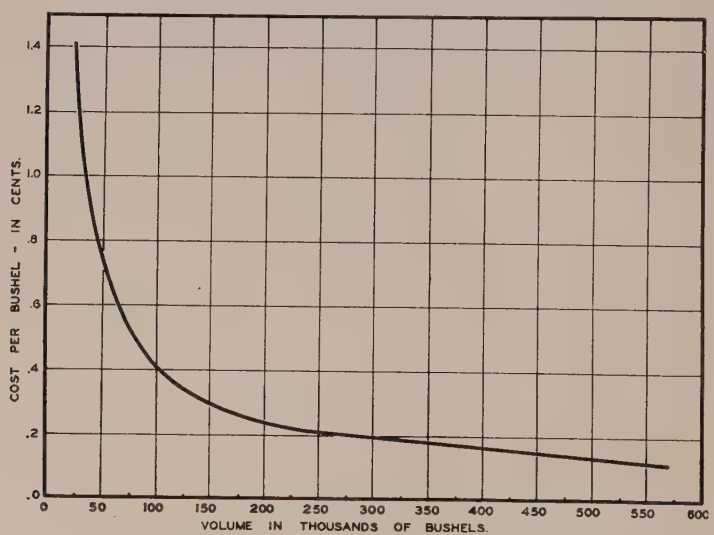

Fig. 11. Relation of Annual Equipment Costs per Bushel to Volume

Equipment costs decrease rapidly with increases in volume up to 150,000 bushels. This curve is of the form $y = a - \frac{b}{x}$.

point it is 0.4 cent. The cost continues to decrease in elevators beyond this volume, but at a diminishing rate. Above approximately 200,000 bushels the reduction is not so significant, the difference between 200,000 and 500,000 bushels being only 0.1 cent, an average decrease of 0.03 cent per bushel for each 100,000 bushels.

Twenty-nine of the elevators were equipped with cleaners, altho 16 of them were not operated this year. The original cost of the cleaning equipment varied from $500 to $2,575, with an average of $1,015. There was no relation between the volume of grain handled and the amount spent for cleaners. Some of the smaller elevators had cleaners of largest capacity. They cleaned more grain than those with larger storage capacity and handled a much larger volume. This variation in the amount invested in cleaning equipment and in utilization of cleaners must cause some of the variations in equipment cost for elevators handling the same volume.

Scales and dumps are another cause of variation. Some elevators, using automatic scales, had an investment as high as $1,400 for weighing out the grain; others, with a hopper scale, as low as $285. An air dump tended to raise equipment costs, for the elevator so equipped often handled no greater volume than before it was added or than elevators having hand dumps. Competition with other elevators may have made it necessary to install such a dump, but this does not prevent an increase in costs. The combined valuation of scales ranged from $570 to $2,350. The low-cost elevator handled 90,000 bushels, the high-cost elevator only 108,000 bushels.

Elevators handling the same volume also have a great variety of power and transmission equipment. These range from gas engines of the semi-diesel type to high-speed electric motors costing much less. Some elevators use a rope drive, which costs much more than a short chain drive, from a motor located in the cupola.

The combined valuations of the cleaner, scales, dump, motors or engine, and drive of the elevators handling 90,000 and 108,000 bushels were $1,400 and $4,725, respectively, regardless of the fact that the volumes were close. Variations in construction and in materials used in pits and boots, type and size of buckets and elevating machinery were further causes of variation in equipment costs.

In equipping many elevators, little consideration seems to have been given the cost of handling grain or the probable maximum volume to be handled at any one time. Since the equipment was purchased, changes may have been made in the policy of cleaning grain. In other cases labor costs may have been reduced, altho previous discussion points out that elevators with large amounts of equipment generally have labor costs little or no lower than some less completely or less expensively equipped.

Other Costs

Other elementary costs of local elevator operation are electricity and gasoline, insurance on grain, taxes on grain, interest on grain holdings, and miscellaneous items, all of which except interest were charged at

whatever was actually expended for them during the period studied. All were variable quantities. The increase in the amount of each tends to be constant for every increase in volume. There is only a slight decrease in the unit costs as the volume becomes larger, with the possible exception of taxes.

Electricity and Gasoline

The cost of electricity and gasoline also includes cost of oil. The average cost for elevators with volumes under 50,000 bushels is 24 cents per 100 bushels and for those with volumes ranging from 100,000 to 150,000 bushels, 20 cents. The cost is somewhat lower for the larger volumes owing to superior equipment and management in larger elevators. Also, there is less stopping and starting of the power per bushel of grain in the large elevator than in the small one. This results in some saving.

Insurance on Grain

The insurance on grain depends upon the stock ordinarily held by the elevator. This, in turn, depends on both the selling policy of the elevator and the amount of farmers' grain held in storage but not yet purchased. Insurance may be carried on the provisional premium adjustment plan, under which a maximum blanket policy is taken out. A weekly report of the amount and value of grain and merchandise on hand is sent to the insurance company and the premium charged is on the basis of the amounts so reported. This should result in a rather close adjustment between the amount of grain in the elevator and the amount of insurance carried so that at all times the grain is fully but not over insured.

Another plan is to carry a given amount of insurance and to take out additional policies as the amount of grain increases. Policies are cancelled as stocks are reduced. Unless given careful attention the adjustment between the value of the grain and the amount of insurance carried at any given time under this plan will not be so exact as by the other method. This causes some variation in insurance costs between elevators but the difference is not enough to obscure other causes for variations. This cost of insurance prorated over the amount of grain handled during the year may be regarded as the cost of insurance per bushel. As a rule, the average stocks of grain are a much greater proportion of the total volume in elevators handling 25,000 to 50,000 bushels than in those handling 200,000 bushels or more. For that reason the average cost per bushel is smaller for elevators handling the larger volumes. For elevators of 25,000 to 50,000 bushels volume, the cost of grain insurance was 20 cents per 100 bushels; for 100,000 to

150,000 bushels, 15 cents; for 200,000 to 250,000 bushels, 8 cents; and for 250,000 bushels and more about 4 cents.

Taxes on Grain

Grain taxes depend entirely on the volume of grain. In any year they vary directly with the volume, as the tax is a state turnover tax and is levied at a given amount per bushel of grain handled—one-half mill for wheat and flax and one-fourth mill for other grains, regardless of their value. Therefore for any grain or in elevators handling similar proportions of different grains, the tax per bushel is constant and is the same in any part of Minnesota.

Interest on Grain

The practice of elevators with regard to holding their purchases at country points is one of the principal reasons for variations in the interest on grain. The percentage of the total annual volume of which an elevator retains ownership is relatively larger with the elevator doing a small business than with one doing a large business. This is due partly to the smaller turnover of many elevators of small volume and a consequent tendency to store relatively more to earn carrying charges, and partly to the relatively larger amount of grain stored for farmers by the larger elevators. Elevators doing a large business generally store such a large part of their receipts for patrons that they are forced to ship out a part of the grain in storage. The elevator may derive some interest on the proceeds from the sale of such grain or it may use the proceeds in its business, which amounts to the same thing. The four elevators handling 250,000 bushels and more, for example, kept their stocks so low that they earned more from interest on the proceeds of sales of grain stored for others than the interest on the investment in the grain they owned. Their average net profit from interest was 5 cents per 100 bushels of grain marketed.

As a result of these conditions, variations in interest costs, as indicated in Figure 12, are much greater between elevators of small volume than between those of large volume. Indeed, variations between elevators marketing more than 125,000 bushels are almost negligible. The cost per 100 bushels varies from 50 cents for elevators marketing 50,000 bushels to 10 cents for those marketing 400,000 bushels.

Variations in interest costs between elevators are also partly due to differences in the combinations of grain marketed and hence to differences in capital requirements. Elevators with similar volumes, for example, incur different costs because the value of their grain varies. For a similar reason, in seasons of important price movements, interest costs vary because of differences in time of buying and of selling grain.

Miscellaneous costs include telephone, telegraph, and market news service. This cost is more or less constant for any elevator, the result

being that costs per bushel are generally lowest for elevators doing the largest business. The costs per 100 bushels range from 11 cents in the group of smallest volume to 3 cents in the group of largest volume.

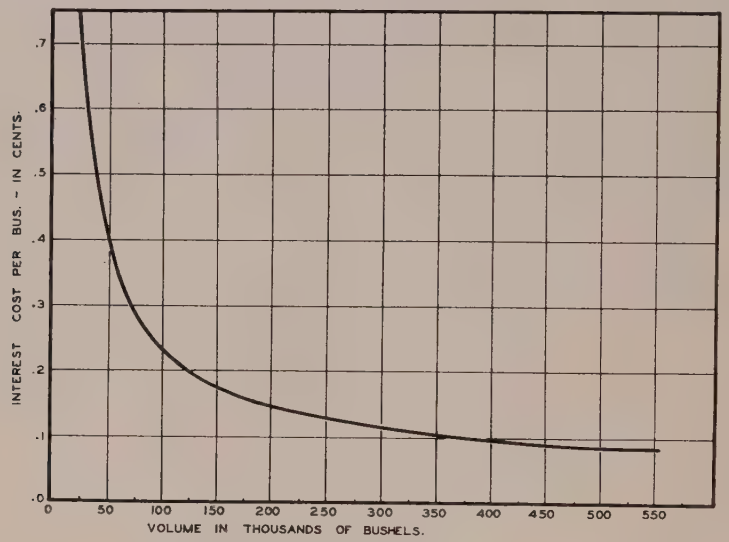

Fig. 12. Relation of Interest Cost per Bushel of Grain to Volume

Elevators with a large business, on the other hand, have highest auditing costs, because they employ more experienced auditors and have a more complete analysis made. Moreover, a large proportion of the large elevators are audited by certified public accountants. A complete audit is frequently not possible in the smaller elevators. Also there is a tendency for the smaller elevator to employ an auditor whose charge for services is low regardless of the quality of his work. Many exceptions could be cited to these statements. They should be understood as tendencies.

Miscellaneous supplies include office supplies and materials for lining cars or preparing them for shipment. The latter is a small part of the total. Per bushel costs decline at a rate almost constant between elevators of different volumes. The cost for the group of elevators with a volume of less than 50,000 bushels is 34 cents per 100 bushels; for the group of from 100,000 to 150,000 bushels, 22 cents; and for those with more than 250,000 bushels, 12 cents. The average cost for all miscellaneous items is 30 cents per 100 bushels and is 8.66 per cent of the entire cost. This is a larger proportion than for any group except labor and management, buildings, and equipment. The possibility of reduction in combined miscellaneous items is therefore of some significance but not large for any one.

Costs of Individual Grains

Determining costs of marketing individual grains involves the distribution of many expenses. The division of costs between grains and sidelines must first be made. The problem of building and equipment cost is, for the most part, one that can be easily disposed of, as the sidelines are ordinarily in a separate building. Whenever the elevator building is used for housing merchandise, as, for example, twine in the driveway during the harvest season, no charge for the use of the building should be made against the sideline enterprise as no additional cost is incurred by the grain business. However, any additional cost incurred by reason of the sidelines is properly a charge against that part of the business.

Labor costs are more difficult to allocate properly. The manager's time, in most instances, is required regardless of whether or not any sidelines are carried. The manager employed is ordinarily no more competent than if no sidelines are carried. The number of helpers or the amount of labor necessary to carry the sidelines may be increased. The proportion of such extra labor required was left to the judgment of the manager. Other expenses—auditing, insurance, taxes, and interest—were divided between grain and sidelines on the basis of actual costs obtained from records. Each was then distributed to the different grains on the basis that seemed most logical.

Labor and management costs per bushel do not vary to any marked extent for different grains. The time required to handle any grain includes that spent in record keeping and in putting it through the elevator. The work required on record keeping is approximately proportional to the number of loads brought to the elevator; the cost was divided among the different grains on this basis. Any labor and management that can not be accounted for by this method, as when the manager is idle or waiting for business, is thus prorated in proportion to the actual time employed on each grain. If wheat requires more labor than other grains, the amount of time allocated to wheat that is not used directly on the grains or in record keeping will be greater than for any other grain.

A distribution of equipment costs as well as of gasoline and electricity costs on the basis of the time the equipment is used for each grain is equitable. This time can be measured by the total time required for carrying each grain through the elevator. Any additional processes, as cleaning or moving the grain in order to condition or mix it, must be considered in addition to the regular processes. The calculation of any extra costs for gasoline, oil, electricity, or labor resulting from such processes can be made fairly accurately. Costs from wear on the machinery may not be so accurately determined. If an engine and ele-

vating equipment were operated an extra 20 hours, what would be the additional cost in depreciation or maintenance? Actually, the cost of such additional work was almost negligible, as only one elevator did any mixing. There was little conditioning and only a small amount of any grain was cleaned.

The distribution of building costs should be made as nearly as possible according to the amount of storage space required by each grain and the time such space is used. It might be argued that as the plant is necessary to handle all the grain, the amount of each grain handled is the proper basis of distribution. If one of the grains with small receipts were not handled, about the same sized elevator would be required. Some grains are held in storage for a long time. Other grains, the volume of which is large, are stored for relatively short periods, if space time is prorated per bushel. Yet the whole elevator is necessary to take care of each bushel even if it passes directly through. Therefore, is not the distribution of building costs on the basis of the number of bushels of each kind of grain handled the most equitable? Or might it not be maintained further that as (according to the managers' opinions) the total volume of grain would be reduced at least by the amount of this grain, the grains handled in small quantity should bear no part of the expense? The existing plant is already built and is there primarily to handle the grains with larger volume, but if it can take on any grains with a small volume there is no additional cost so far as buildings are concerned. However, by this method of distributing costs an arbitrary distinction would have to be made between grains varying in volume. The authors believe that the use of building space for the various grains contemplates more than these statements assume. Approximately the same number of bushels of grain handled in large quantities may be put through an elevator even if the other grains were not handled, but these grains probably incur a higher cost for the service they receive than if the grains handled in small quantities were not marketed. For example, wheats of different commercial value may be thrown together that would otherwise be kept separate. Shipments may be made early because storage space is at a premium for the most important grains in time of car shortage. Moreover, if the elevator is constructed to handle only one or two grains, the size and details of construction might be altered.

On the basis of this method, if 100,000 bushels each of corn and oats and 1,000 bushels of flax were handled and two-fifths of the storage space was occupied by corn during the year, two-fifths by oats, and one-fifth by flax, the total charge for building space would be divided in the ratio of 2, 2, and 1, but bushel costs would be in the ratio of 0.2, 0.2, and 1.0, respectively. The annual building charge per bushel for flax is therefore fifty times that for corn or oats. This probably

more nearly approaches the economic costs over the life of the elevator than any other method of distribution.

Costs of gasoline, electricity, and oil were distributed to each grain on the basis of the time required for power in processing each. Interest on purchased grain depends on the value of each kind of grain owned by the elevator during each unit of time. The average value of each grain by months was obtained from the records of purchases and sales, and interest on money invested in grain was calculated at the rate paid by the elevator for its financing. By this method interest costs were allocated to each grain in accordance with the average monthly investment.

Taxes, being uniform over the state, were charged according to tax rates. Insurance charges were distributed in proportion to the value of average weekly stocks of each grain on hand, which in most elevators is the basis of premiums paid. Auditing charges were allocated according to the number of loads of each grain received, as the number of entries varies almost directly with the number of loads.

Market news information is of value only as it increases gains or prevents losses in purchases and sales. These losses or gains are likely to occur in proportion to the value of the grain. A distribution of this item on the basis of grain values is most desirable. Supplies for coopering cars are used approximately according to the number of cars of each grain shipped. Flax requires more labor and material than other grains, but differences in costs are so small that they may disregarded. Office supplies and other miscellaneous items amount to a very small percentage of the total. A distribution of these costs on the basis of grain values, while somewhat arbitrary, is equitable.

Wheat

High, low, and average costs of wheat and of all grains combined, as given in Table XIX, are similar, partly because wheat is an important part of the total but chiefly because the causes of variation are common to the two. The most notable exception is the high cost of 10.1 cents per bushel for wheat among elevators handling over 250,000 bushels. This high cost, occurring in an elevator whose average cost was low, was the result of handling only 671 bushels of wheat. A bin was allotted to the wheat for almost the entire year. Interest and insurance costs were therefore incurred for a relatively longer period than for the other grains. There was not enough grain for a carload and shipment finally had to be made as a bulkhead with other grain when it appeared there would not be enough to fill a car. If hedging costs were included, the total cost would probably have been even higher, as hedging gains and losses are more likely to occur when grain is hedged over a long period.

TABLE XIX

RELATION OF VOLUME TO HIGH, LOW, AND AVERAGE COSTS OF WHEAT AND OF ALL GRAINS

Group	No. of elevators		Range in volume		Cost of all grains			Cost of wheat		
	All grains	Wheat	All grains	Wheat	High	Low	Average	High	Low	Average
			bu.	bu.	cents	cents	cents	cents	cents	cents
1	11	11	0– 50,000	4,479– 28,428	12.1	5.0	7.7	12.5	5.3	8.4
2	17	15	50,000–100,000	4,358– 53,051	10.2	3.4	5.3	12.1	3.8	6.2
3	11	11	100,000–150,000	11,753– 80,210	6.3	2.4	4.6	7.3	3.5	5.7
4	4	4	150,000–200,000	2,575– 36,524	3.5	1.9	2.7	6.1	3.1	4.5
5	2	2	200,000–250,000	40,501–102,834	2.7	2.4	2.5	3.5	3.2	3.3
6	4	4	More than 250,000	671– 65,833	2.5	1.1	1.5	10.1	3.1	3.2
Weighted average	49	47	.....	.....	...	...	3.6	...	...	3.8

Interest and insurance costs for wheat are normally higher per unit of time retained in the elevator than for other grains except flax, because of its higher value. However, if wheat is shipped out more promptly than other grains, as is sometimes the case, these costs may be no higher and may even be lower. Labor and equipment costs per bushel depend on the time required to handle the grain. As the amount of labor is largely dependent on the rate at which the grain can be elevated, and that varies directly with the bushel weight of the grain, the labor costs may be slightly higher for wheat of high test weight than for any other grain. Cost of storage space is dependent on the policy in shipping out the grain and the rate at which it is received. Costs for the use of buildings, according to the method of allocation employed here, are almost invariably lowest for the grain handled in largest amount. Other costs of handling wheat, because of both heavier weight and greater value per bushel, tend to be higher than for other grains except, possibly, flax.

Variations in the volume of all other grains and of wheat together account for 45 per cent of the variability in the cost of handling wheat between different elevators, of which 35 per cent is due to the volume of all grains and 10 per cent to the volume of wheat.[10] Altho the volume of wheat is of some significance in determining variations in costs, the volume of all grains is much more important. The relative importance of the two factors is not the same at all volumes, however. Variation in the volume of wheat is relatively more important when the volume is small, and variation in the volume of all grains is relatively more important when the volume of wheat is large, because variations in the cost of handling wheat or any other grain are large for a given variation in volume when the volume is small, owing to variation in the use of storage space. Data indicate that storage space allotted by elevators handling less than 5,000 bushels of wheat was not well utilized and that the cost of handling less than this amount increased rapidly with decreases in volume.

A similar analysis for other grains shows practically the same relation. It therefore appears that if it is necessary for a manager to handle all kinds of grain offered in order to secure business, he should adopt a policy that would assure him a sufficient volume of each to use all the cost factors economically, the chief factor being storage space. In some instances it may be desirable to encourage patrons to produce more of the grains grown in small quantities, particularly

[10] A correlation of wheat costs, with volume of all grains and volume of wheat as the independent variables, gives a multiple coefficient of correlation of 0.67. In order to make the correlation it was necessary to use the reciprocals of volumes of wheat and other grains because linear relationship was unusual. However, a gross curvilinear relationship between cost and volume, as indicated by one of the curves of Figure 13, would differ very little from this.

where they can be produced to advantage. In other instances it may be advisable to pay a higher price to get the volume than would otherwise be justified, as a small loss or a small profit is preferable to a large loss or no profit. An additional compensation for such a policy is the advertising value of the high prices paid for such grain.

Other Grains

Grains other than wheat will be considered in one group. Oats was bought by every elevator, and was handled at a lower cost per bushel than any other grain. It is lighter, can be handled more rapidly, and, the value being lower, interest and insurance costs are lower. As it is generally handled in medium to large quantities the expense for storage space is low.

Flax weighs almost as much as wheat. It requires more moving to keep in condition and more labor to prevent leakage in bins and cars. Insurance and interest costs are higher because of the greater value. It is often handled in small quantities, hence at higher building costs.

Costs for corn, barley, and rye fall between those of wheat and oats but nearer the cost of oats, the principal reasons for variation from oats being differences in value and volume. This was important in determining the utilization and cost of storage space assigned to them.

Costs of handling each grain tend to be smaller for elevators having the larger business, and altho there is some variation in the costs of the different grains for given changes in volume, they tend to vary at approximately the same rate. (See Fig. 13.) This tendency is undoubtedly due to the much greater relative effect of total volume on costs than of the volume of any one grain.[11] The relative cost of handling the different grains by elevators of different volume depends upon the combination of grains handled. The large elevators were located chiefly in southwestern Minnesota, where the volume of wheat and flax was small and the volume of the other grains, particularly corn and oats, was large. Wheat and flax costs are therefore relatively larger than they would be for elevators of similar size in an important wheat and flax territory.

Combined Costs

The extreme range in total costs between elevators was from 1 to 12 cents per bushel. The ordinary range may be considered from

[11] The influence of total volume of all grains and volume of each grain on the cost of any one grain is expressed as follows:

Grain affected	Effect of total volume of all grain per cent	Effect of volume of each grain per cent	Grain affected	Effect of total volume of all grain per cent	Effect of volume of each grain per cent
Flax	39	9	Corn	41	17
Wheat	35	10	Barley	47	6
Rye	41	17	Oats	44	22

2 to 10 cents. The weighted average cost was 3.6 cents. Table XX shows that expenses of labor and management, building, and equipment are 46.5, 20.4, and 11.7 per cent, respectively, of the total expense. Gasoline, electricity, and oil, as one item, constitute 4.1 per cent, and interest on grain 4.7 per cent. The other 12.5 per cent is made up of taxes and insurance on grain, marketing information, telephone and telegraph service, auditing, and a miscellaneous group that was largely office supplies. The percentages show the proportion of the total cost made up by each item; they do not indicate the relative importance of each in explaining variations in total costs.

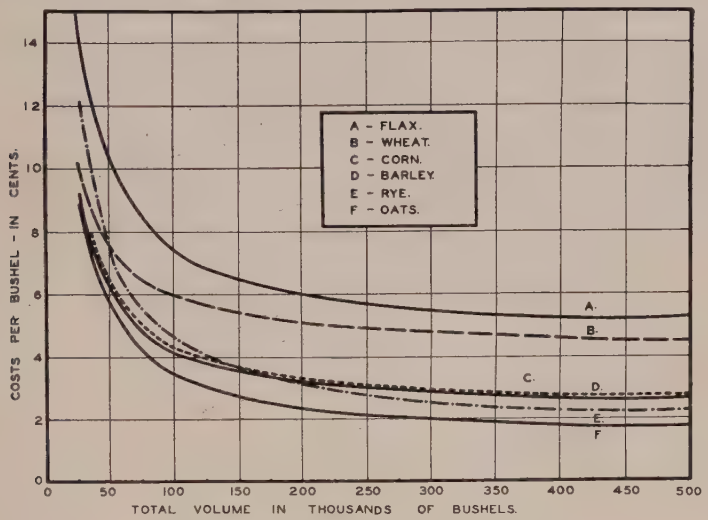

Fig. 13. Costs of Handling Different Grains
These costs tend to decrease as the volume of grain increases.

Volume and Costs

Volume is an important factor causing variations in elementary costs, as pointed out previously. Total costs, which are made up of elementary costs, must therefore be similarly affected. Variations in labor and management costs, it will be noted from Table XXI and Figure 14, account for the greatest variation when total costs are considered in relation to volume. Building costs are second in importance, equipment costs third, and interest on grain fourth. The total of the other cost items varies almost directly with variations in the volume of grain handled. Consequently the possibility of greater economies in the use of these elements is small. Gasoline, electricity, and oil are the largest items of the miscellaneous group and altho the slope of this curve (F in Fig. 14) shows variations in cost with variations in volume, elevators with large volume are enjoying no important advantage when competing with a business of smaller volume.

TABLE XX

PERCENTAGE OF TOTAL COSTS REPRESENTED BY EACH ITEM FOR ELEVATORS OF DIFFERENT VOLUMES

Volume	No. of elevators	Percentage of total cost										
		Labor and management	Building	Equipment	Electricity and gasoline	Interest on grain	Taxes on grain	Insurance on grain	Market information and phone	Auditing	Supplies and miscellaneous	Total
bu.		per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
0– 50,000.....	11	41.3	25.7	14.2	3.1	6.6	0.6	2.1	1.5	0.3	4.4	100
50,000–100,000.....	17	46.7	22.4	11.8	3.1	5.5	0.6	2.6	1.9	0.7	4.7	100
100,000–150,000.....	11	45.9	19.0	11.5	4.3	6.6	0.8	3.2	1.6	2.1	5.0	100
150,000–200,000.....	4	47.1	16.3	12.9	4.7	6.1	1.1	1.7	1.7	1.4	7.0	100
200,000–250,000.....	2	50.0	16.0	10.9	5.0	2.8	1.4	3.4	2.0	2.7	5.8	100
More than 250,000.....	4	51.8	17.8	9.8	6.5	—3.6	1.8	2.6	2.2	3.2	7.9	100
Weighted average..	49	46.5	20.4	11.9	4.1	4.7	0.9	2.8	1.8	1.5	5.4	100

TABLE XXI

ITEMIZED COST OF OPERATION FOR ELEVATORS OF DIFFERENT VOLUMES

Volume	No. of elevators	Cost per bushel										
		Labor and management	Building	Equipment	Electricity and gasoline	Interest on grain	Taxes on grain	Insurance on grain	Market information and phone	Auditing	Supplies and miscellaneous	Total
bu.		cents	cents	cents	cents	cents	cents	cents	cents	cents	cents	cents
0– 50,000.....	11	3.18	1.98	1.09	0.24	0.50	0.04	0.20	0.11	0.92	0.34	7.70
50,000-100,000.....	17	2.45	1.17	0.62	.16	.29	.03	.14	.10	.04	.25	5.25
100,000–150,000.....	11	2.10	0.87	0.52	.20	.30	.04	.15	.07	.10	.22	4.57
150,000–200,000.....	4	1.25	0.43	0.34	.13	.16	.08	.05	.05	.04	.19	2.67
200,000-250,000.....	2	1.26	0.40	0.27	.13	.07	.04	.08	.05	.07	.15	2.52
More than 250,000.....	4	0.76	0.26	0.14	.10	—.05	.03	.04	.03	.05	.12	1.48
Weighted average ..	49	1.67	0.73	0.43	0.15	0.17	0.03	0.10	0.06	0.05	0.19	3.58

Total costs, like elementary costs, vary between elevators with different volume. Variations in volume up to 200,000 bushels are accompanied by relatively large variations in costs. Elevators handling 25,000 and 50,000 bushels have costs of 10 and 6.3 cents, respectively; elevators with 50,000 and 75,000 bushels, 6.3 and 5 cents, respectively. Beyond 200,000 bushels, however, costs vary less with differences in volume

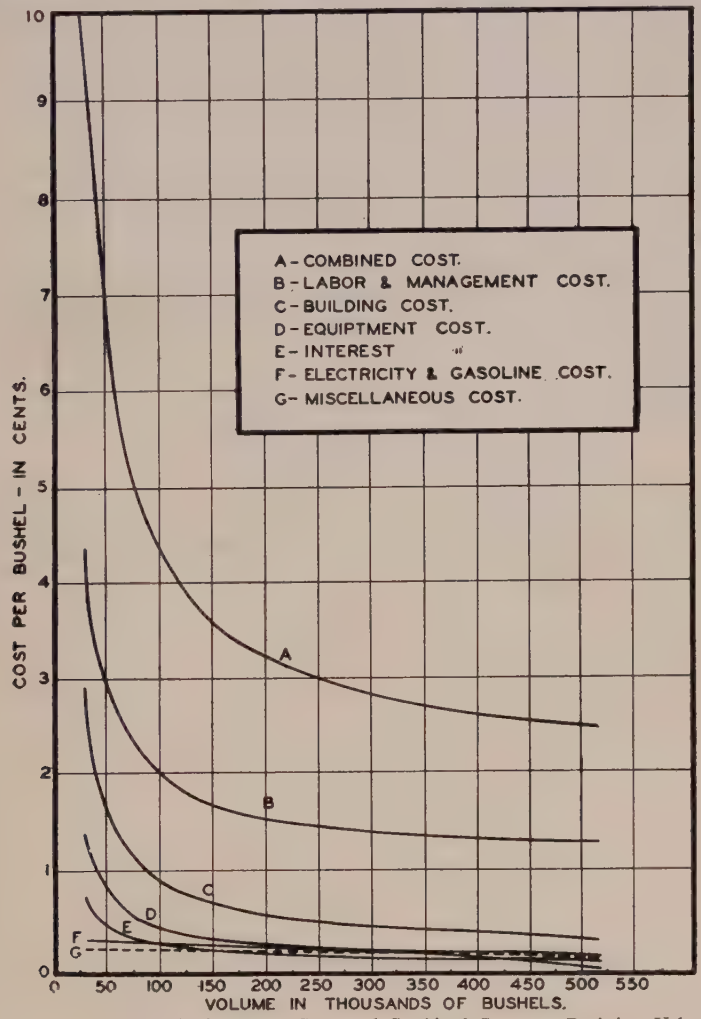

Fig. 14. Relation of Elementary Costs and Combined Costs per Bushel to Volume

and the rate of variation decreases as volume increases, altho it continues to decrease even for the largest volume groups of this study.

The principal reason for the lower costs is that labor and management, storage space in buildings, and equipment, particularly, are more

fully utilized in elevators handling large volumes. At a volume of about 200,000 bushels, as previously stated, an elevator association generally takes on another regular helper, and costs decrease less rapidly thereafter for increases in volume. In districts where grain production is increasing, after a certain point is reached an additional leg may become a necessity and the size of equipment must be increased. Up to a certain point, maximum use is not made of the plant and the hired labor. Elevators having volumes of more than 200,000 bushels use these factors better than smaller organizations. Moreover, larger volume probably gives an elevator more effective utilization of the old as well as the new units.

Maladjustments are usually found in all elevators. Too much labor for the volume of business is the most frequent. Too large an elevator for the available volume is another. This may result from shifts in the type of farming or from poor judgment when the elevator was built. The life of the equipment is shorter than that of the building and adjustments may be made more rapidly in this factor, but even here changes must be comparatively slow. An elevator that is being built can be planned to fit the present volume.

Other Elements Affecting Costs

Costs of operation, also, vary because of different use of the cost elements. Elevators with volumes ranging from 100,000 to 150,000 bushels, for example, had total costs ranging from 6.3 cents to 2.4 cents per bushel. Labor and management costs for the same elevators ranged from 3.8 to 1.5 cents per bushel; equipment costs from 0.71 to 0.07 cent; and building and site costs from 1.03 to 0.48 cent. An analysis of other volume groups gives similar results.

The variability of total costs is affected differently by the various cost elements. An analysis of data for the entire group indicates that after the effect of volume has been eliminated, 56 per cent of the variability was due to labor and management costs, 35 per cent to equipment costs, 6 per cent to building and site costs, 1 per cent to interest on grain stocks, and 2 per cent to other costs. These data are of interest for elevator associations that wish to become more efficient, particularly as the cost factor that varies most widely, labor and management, is the largest single cost and the most easily changed of any of the important cost elements. Not all boards of directors can reduce their labor and management costs to correspond to the lowest cost of elevators of the same volume. Labor costs are sometimes high because other costs are low, as when labor is substituted for equipment. Nevertheless, the data indicate that labor and management adjustments have been made in some elevators and there is good reason to believe that they can be made in others.

Moreover, equipment, the second most important factor affecting total costs, is next to labor and management the most easily changed of the major cost elements. Adjustments in equipment can not be made rapidly, but replacements are frequent enough to bring about slow adjustments.

The fact that only 6 per cent of the variability in total costs is due to building expense indicates that the adjustment between size of building and volume is relatively good and offers another proof of the standardization of elevator construction.

Variation in interest on grain stocks, which accounts for 1 per cent of the variation in total costs, depends largely on the policy of the elevator—whether a considerable amount of its own grain is held or is shipped out as fast as received. This may not need serious attention, as added premiums received may offset any increase in cost.

The remaining items, included in a miscellaneous group, cause slightly less than 2 per cent of the variation in total cost. Gasoline and electricity and insurance on grain are the most probable causes of variation within this group. Increases in insurance cost due to stored grain may be compensated for by storage charges. The possibilities of reducing the causes of variation in the miscellaneous group are therefore not significant.

Sidelines

The relative importance of the different cost elements for elevators of different volume can not be determined from available data. There may be a variation in the degree of adjustment of the elements to each other for businesses of varying size, but not sufficient to modify the general conclusions. This does not mean that there are equal possibilities of improving the organization for elevators of different volume, because the wider range in total costs of the elevators of small volume, as given in Table XXII, and the wider range in cost of the different elements for the same groups indicate that there are greater possibilities of saving through economic reorganization in small elevators than in large ones. On the other hand, any elevator, irrespective of volume, can generally effect its largest economies by better adjustment of labor and management and equipment to the business.

The sideline business, as conducted by elevators in Minnesota, appears to have little effect upon the cost of handling grain.[12] Only a few elevators employ more labor and a higher grade manager because of the sideline business. The sidelines are generally handled in order to make better use of the building and labor provided to market grain. The measure of increased efficiency resulting from the addition of sidelines should therefore be income instead of costs.

[12] The coefficient of correlation between total cost per bushel and per cent that sideline sales are of total sales is 0.18.

TABLE XXII

HIGH, LOW, AND AVERAGE TOTAL COSTS FOR ELEVATORS OF VARIOUS SIZES

Volume	No. of elevators	Cost per bushel of grain		
		High	Low	Average
bu.		cents	cents	cents
0– 50,000	11	12.1	5.0	7.7
50,000–100,000	17	10.2	3.4	5.3
100,000–150,000	11	6.3	2.4	4.6
150,000–200,000	4	3.5	1.9	2.7
200,000–250,000	2	2.7	2.4	2.5
More than 250,000	4	2.5	1.1	1.5
All groups	49	12.1	1.1	3.6

The gross sideline income of the 27 elevators of this study that were handling sidelines ranged from $118 to $9,769 and averaged $1,609 per elevator after deducting transportation and draying costs. This represented from 4 per cent to 56 per cent of the gross income from sales of grain and sidelines for individual elevators and averaged 23 per cent of all sales. These elevators are representative of elevators over wide sections of the hard red spring wheat area.

The sideline business, on the other hand, has been a liability to the grain business in a few instances, particularly where credit was granted freely or where many sidelines were handled. The five elevators of this study that handled lumber and machinery or a combination of the two were in poor financial condition from these sources. Each elevator did some credit business and had some bad accounts. Directors agreed almost universally that a more capable manager is needed to handle sidelines and grain than to handle grain alone, or grain and a few such lines as fuel, feed, flour, and twine, the handling of which requires little supervision or extra labor. This is especially true where hedging and insurance, based on stocks and purchases reported by the manager, are left to the commission firm and where consequently a manager may be hired at a lower salary to handle the grain business.

BEST BUSINESS SET-UP FOR A LOCAL ELEVATOR

It is not the purpose of this study to point out the size of building or amount of labor and equipment for an elevator in any community. Conditions affecting efficiency vary too widely and available data do not allow analysis in sufficient detail. Volume of business is affected by type of farming, character of roads, and number of competitors and degree of competition offered by them. Moreover, the amount and quality of services demanded by patrons, as well as the kind and character of grains marketed (important factors affecting business practices and costs) vary widely between local markets. Each elevator organiza-

tion must therefore decide how its business should be set up to operate most successfully under its peculiar conditions.

SUMMARY

The foregoing analysis indicates several important factors that affect efficient organization. They may be summarized as follows:

1. **Volume of business.**—Elevators of large volume have an advantage over those of small volume. Elevators marketing less than 125,000 bushels of grain have substantially higher costs than those marketing larger volumes. Costs of operation vary widely between different volumes in the same elevator. Getting business, therefore, is important.

2. **Labor and management.**—This is the most important factor, except volume, affecting costs. Fortunately it can be changed more easily than other important factors. The amount of labor used is much more important than the rate paid. Elevators marketing less than 100,000 bushels and doing an ordinary sideline business can not afford to employ more than one regular man, and if the elevator is well equipped it may be able to handle up to 200,000 bushels, especially where combinations of grains (as corn and oats) more completely utilize labor because the maximum receipts occur at different times.

3. **Equipment.**—Economy may sometimes be realized by better adjustment of the size and cost of equipment to the probable volume and sometimes by not purchasing unnecessary equipment. As a specific example, we may point to the 16 idle cleaners found among the 49 elevators included in this study.

4. **Buildings.**—Buildings are much better adjusted to the business than is either equipment or labor. Realization of a smaller volume than was planned for when the elevator was constructed is one of the important causes of maladjustment. Proper consideration for possible future changes in farming is important when an elevator building program is contemplated in a state such as Minnesota, where important shifts in type of farming are under way.

5. **Sidelines.**—Altho the handling of sidelines makes possible a more complete utilization of buildings and labor, it does not substantially increase or decrease the cost of marketing grain under the usual conditions among elevators in Minnesota. Sidelines do increase the income, however, and thus increase the efficiency of the elevator business when they are properly merchandised.

6. **Bookkeepers.**—Most farmers' elevators can not afford to employ a clerk, but when hiring a manager more attention might profitably be given to his ability to keep records. The superior control of the elevator afforded by good records makes a manager thus qualified to handle the business an asset to the enterprise even if he may command a somewhat higher salary.

BIOGRAPHY

Hutzel Metzger was born December 12, 1894, at Athens, Tennessee. He was reared on a farm; attended high school at Grandview, Tennessee, and Riverside, California. He taught in grade and high schools in the State of Washington from 1911 to 1914. In 1916 and 1917 he served as a private in infantry, Mexican Border Service; and from 1917 to 1919 as first lieutenant (pilot), United States Air Service.

The North Dakota Agricultural College granted him the degree of Bachelor of Science in Agriculture, in 1920; and the degree of Master of Science in Agricultural Economics in 1923. He served this college as assistant agricultural economist in 1920-21; and as associate agricultural economist in 1921-23. From 1923 to 1925 he was research assistant in the University of Minnesota; and in 1925-26 was a fellow of the Social Science Research Council. He was granted the degree of Doctor of Philosophy by the University of Minnesota in June, 1926.

He is a member of the following: Alpha Zeta, Phi Kappa Phi, Delta Gamma Sigma, Alpha Gamma Rho, and the National Grange.